REPORT OF THE

ROYAL COMMISSION

ON THE MINERAL RESOURCES OF ONTARIO

AND MEASURES FOR THEIR DEVELOPMENT.

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ERRATA.

Page 2—Between Utica and Medina Formations insert "Hudson River Formation."
" 15—Lines 3 and 11 from top, for "fifty" read "thirty."
" 46—Line 19 from top, for "Devonshire" read "Devonian."

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THE COMMISSIONERS.

JOHN CHARLTON, M.P. for North Norfolk, Lynedoch.

ROBERT BELL, M.D., LL.D., Assistant Director of the Canadian Geological Survey, Ottawa.

WILLIAM COE, Explorer and Miner, Madoc.

WILLIAM HAMILTON MERRITT, F.G.S., Associate Royal School of Mines, Toronto.

ARCHIBALD BLUE, Deputy Minister of Agriculture and Secretary of the Bureau of Industries for Ontario, Toronto.

THE COMMISSION.

A. CAMPBELL.

ARTHUR S. HARDY Attorney-General pro tempore under R. S. O. cap. 13, sec. 3.	PROVINCE OF ONTARIO: VICTORIA by the Grace of God of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, etc., etc., etc.

To John Charlton of the village of Lynedoch, in the county of Norfolk, Robert Bell of the city of Ottawa, in the county of Carleton, William Coe of the village of Madoc, in the county of Hastings, and William Hamilton Merritt of the city of Toronto, in the county of York, Esquires, our Commissioners in this behalf, Greeting:

WHEREAS in and by chapter seventeen of the Revised Statutes of Ontario it is enacted that whenever the Lieutenant-Governor in Council deems it expedient to cause enquiry to be made into and concerning any matter connected with the good government of our Province of Ontario or the conduct of any part of the public business thereof or the administration of justice therein, and such enquiry is not regulated by any special law, the Lieutenant-Governor may by the Commission in the case confer upon the Commissioners or persons by whom such enquiry is to be conducted the power of summoning before them any party or witnesses and of requiring them to give evidence on oath orally or in writing (or on solemn affirmation if they be parties entitled to affirm in civil matters) and to produce such documents and things as such Commissioners deem requisite to the full investigation of the matters in which they are appointed to examine, and that the Commissioners shall then have the same power to enforce the attendance of such witnesses and to compel them to give evidence as is vested in any court of law in civil cases.

AND WHEREAS it has appeared expedient to the Lieutenant-Governor of our said Province in Council that a Commission under the great seal of our said Province should issue for the purpose of enquiring into and reporting upon the Mineral Resources of our said Province and the Measures for their Development.

NOW KNOW YE that we having and reposing full trust and confidence in you the said John Charlton, you the said Robert Bell, you the said William Coe, and you the said William Hamilton Merritt, do hereby by and with the advice of our Executive Council of our said Province appoint you the said John Charlton, you the said Robert Bell, you the said William Coe and you the said William Hamilton Merritt our Commissioners in this behalf to enquire into and report upon the Mineral Resources of our said Province and the Measures for their Development, giving to you our said Commissioners full power and authority to summon before you any witness or witnesses and to require him or them to give evidence on oath orally or in writing (or on solemn affirmation if such witness or witnesses is or are parties entitled to affirm in civil matters) and to produce to you our said Commissioners such documents and things as you may deem requisite to the full investigation of the premises, together with all and every other power and authority in the said act mentioned and authorised to be by us conferred on any Commissioner appointed by authority or in pursuance thereof. And we do require you our said Commissioners forthwith after the conclusion of such enquiry to make full report to our said Lieutenant-Governor touching the matters concerning which the said enquiry is to be made, together with a return of all or any of the evidence taken by you our said Commissioners respecting the same.

TO HAVE, HOLD AND ENJOY the said office of Commissioners as aforesaid during the pleasure of our said Lieutenant-Governor.

AND WE DO APPOINT you the said John Charlton to be the Chairman of our said Commission.

AND WE DECLARE that it is our will and pleasure that Archibald Blue of the said city of Toronto, Esquire, shall be the Secretary of our said Commission, and we do hereby appoint him Secretary thereof as aforesaid.

In testimony whereof we have caused these our Letters to be made Patent, and the Great Seal of our said Province of Ontario to be hereunto affixed.

Witness the Honorable Sir Alexander Campbell, Knight Commander of our most distinguished Order of St. Michael and St. George, member of our Privy Council for Canada, etc., etc., etc., Lieutenant-Governor of our Province of Ontario, at our Government House, in our city of Toronto, in our said Province, this sixteenth day of May in the year of our Lord one thousand eight hundred and eighty-eight and in the fifty-first year of our Reign.

By Command,

(Signed) ARTHUR S. HARDY, Secretary.

THOMAS GALT, Administrator.

Arthur S. Hardy
Attorney-General pro tempore
under R. S.O., cap. 13, sec. 3.

Province of Ontario: Victoria by the Grace of God of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, etc., etc., etc.

To Archibald Blue of the city of Toronto, Esquire, Secretary of the Commission respecting the Mineral Resources of Ontario and their Development, Greeting:

Whereas under the provisions of chapter seventeen of the revised Statutes of our Province of Ontario we did by our certain Letters Patent and Commission under the great seal of our said Province bearing date the sixteenth day of May in the year of our Lord one thousand eight hundred and eighty-eight appoint John Charlton of the village of Lynedoch, in the county of Norfolk, Robert Bell of the city of Ottawa, in the county of Carleton, William Coe of the village of Madoc, in the county of Hastings, and William Hamilton Merritt of the city of Toronto, in the county of York, Esquires, our Commissioners to enquire into and report upon the Mineral Resources of our said Province of Ontario and Measures for their Development.

And whereas the Administrator of our said Province in Council deems it expedient that you the said Archibald Blue should be associated with the said Commissioners in the said work.

Now therefore know you that we having and reposing full trust and confidence in the loyalty, ability, integrity and discretion of you the said Archibald Blue have constituted and appointed and by these presents do constitute and appoint you the said Archibald Blue to be a Commissioner for the purposes in our said Commission contained and recited, and do associate you the said Archibald Blue for that purpose with the said John Charlton, Robert Bell, William Coe and William Hamilton Merritt, hereby fully and effectually giving and granting unto you the said Archibald Blue all and every the like powers given and granted by our said Commission to the Commissioners therein named and to all intents and purposes as if the said powers and authorities were herein and hereby particularly mentioned and expressed, and as if you the said Archibald Blue had been appointed by said original Letters Patent and Commission.

And we do command the said John Charlton, Robert Bell, William Coe and William Hamilton Merritt to receive you the said Archibald Blue as their said associate.

In testimony whereof we have caused these our Letters to be made Patent and the great seal of our said Province of Ontario to be hereunto affixed.

Witness the Honorable Sir Thomas Galt, Knight, Chief Justice of the Common Pleas Division of our High Court of Justice for Ontario, etc., etc., etc., Administrator of our Province of Ontario, at our Government House, in our city of Toronto, in our said Province, this twenty-fifth day of July in the year of our Lord one thousand eight hundred and eighty-eight and in the fifty-second year of our Reign.

By Command,

(Signed) ARTHUR S. HARDY, Secretary.

Report of the Commission upon

THE MINERAL RESOURCES OF ONTARIO

and Measures for their Development.

To the Honorable Sir Alexander Campbell, K.C.M.G.,

Lieutenant-Governor of Ontario:

The Commissioners appointed to enquire into and report upon the mineral resources of the Province and measures for their development have to state for the information of Your Honor that at their first meeting held in the city of Toronto, after conferring with the members of your Government on the nature and scope of their duties under the terms of the Commission, the following scheme or plan of enquiry was agreed to, viz: *Scheme of the enquiry.*

I. The geology of the Province, with special reference to its economic minerals: assigned to Dr. Bell.

II. Detailed description and maps of the working mines and important undeveloped mineral occurrences of the Province, together with all matters which appertain to mining engineering: assigned to Mr. Merritt.

III. Trade in mineral products, showing exports and imports, shipping facilities for ores, building stones, etc., and a general enquiry into the causes of depression in the mining industry of the country: assigned to the Chairman.

IV. Information and suggestions on the subject of mining laws and regulations, with a view to the giving of greater encouragement to our mining industry: assigned to the Secretary.

V. An enquiry into the best means of promoting the metallurgical industry,

with special reference to the smelting of iron and other ores: assigned to the Secretary.

vi. Other measures for the aid and encouragement of the mining and metallurgical industries, embracing: (1) The organisation of a bureau of mines for the Province; (2) the founding of a geological and mineralogical museum; (3) The collection and publication of mining statistics; (4) Technical instruction in its relation to mining and metallurgy. The first of these subjects was assigned to Dr. Bell, the second to Mr. Merritt and the third and fourth to the Secretary.

Evidence of witnesses.

It was also agreed to as part of the scheme of the report that the evidence of witnesses should be arranged as far as practicable under the foregoing heads, so that each subject or section should be complete in itself and that the distinctive features of the evidence of each witness might appear in their natural and appropriate relation.

Sessions of the Commission for hearing evidence.

Sessions of the Commission for hearing evidence were held at thirty-seven places in the Province, from Ottawa in the east to Rat Portage in the west, and one hundred and sixty-four witnesses were examined under oath, comprising among their number explorers, prospectors, miners, mine and quarry owners, mine captains and superintendents, mine brokers, mining engineers, civil engineers, land surveyors, geologists, assayers, chemists, metallurgists, scientists, iron founders, brick makers, tile, terra cotta and pipe manufacturers, iron makers, copper and nickel smelters, mechanics, lawyers, bankers, merchants, capitalists and speculators. Mines, mining locations and works in the vicinity of places where the Commission met were examined, and careful enquiry respecting them was made.

Special information.

Several other important districts and places were also visited by members of the Commission, with the object of procuring special or desirable information. The extensive magnetic iron ore range in the region west of Lac-de-milles-lacs and the Black Bay lead region on lake Superior were explored by Dr. Bell, while Mr. Coe, Mr. Merritt and the Secretary made a journey to the iron ranges in northern Minnesota, near the Ontario boundary. Mr. Merritt also visited the Michigan School of Mines at Houghton. The Chairman and Secretary in the latter part of 1888 visited the Columbia School of Mines in New York, the office of the Geological Survey at Washington,

and furnaces and steel works at Pittsburg, Pa., at Chattanooga, Tenn., and at Birmingham, Alabama. Another object of the visit to Birmingham was to enquire into the merits and witness the operation of the Henderson process for eliminating sulphur and phosphorus from iron and converting it into steel. An accident to the machinery prevented their observing this process, but they were fortunate in arranging for a careful test and report upon it to be made by Mr. Garlick of Cleveland, Ohio, a metallurgist whose experience in the manufacture of iron extends over a period of twenty-five years. His report appears in the Appendix. The Secretary also visited during the summer of 1889 the laboratory of Mr. Edison at Orange, N. J., to witness the operation of an electrical machine invented to purify and concentrate magnetic iron ores, the Sheffield Scientific School at Yale College, and several iron furnaces and mines in the vicinity of Port Henry on lake Champlain.

Original and historical data of the report.

The data of the report are original and historical. The Commission has not followed in the footsteps of others, but has pursued the course marked out for itself, and it professes to present no inference, opinion or statement of fact which is not warranted by the evidence, the study and observation of its members, or the testimony of the highest authorities.

Sketch of the geology of the Province.

In the Section devoted to the geology of the Province a systematic account is given of each one of its rock formations. This part of the report could not be prepared without employing geological terms, but the simplest expressions have been used and a glossary of many terms has been appended in order that it may be the more easily read by persons unfamiliar with geological science. To make the description more complete and intelligible, it has been deemed necessary to sketch some of the general geological features of North America beyond the borders of Ontario and to touch upon a few of the leading characters in connection with its geology. The aim throughout has been to make a statement of facts only, disregarding everything of a purely theoretical character. This Section has been written with the advantages of a full knowledge of the work of the Canadian Geological Survey from its inception up to the present time, and it embodies the results of the latest researches not only of members of that service but of various other investigators. In its preparation advantage has also been taken of any new or hitherto unpublished information known to the writer.

The reports of the Geological Survey of Canada, although of much value for reference as to details in the various Provinces, are too numerous and too voluminous for the use of any one who can spare only time to acquire a general acquaintance with the geology of his own Province. Moreover as these reports extend back through a period of nearly half a century, most of them are inaccessible to the public, and much of what was stated in the earlier volumes has been superseded, modified or largely supplemented by more recent investigations. The limits of the Province having been recently extended far beyond those which were formerly recognised, any previous account of its geology would now be incomplete, even if the data in reference to the added territory had been available. But no pretence is made to cover the field in this work. A full account of every branch of the subject or of any locality has not been attempted; that would occupy several volumes, and the aim of the Commission has been to present in compact form information upon all matters coming within the scope of its inquiry. The geological Section however embraces the most recent and the best established views on all points, and gives prominence to the Archæan rocks, which cover the greater part of Ontario as now bounded, and which are important from the occurrence in them of various economic minerals in the Huronian and Upper Laurentian systems. The description of the various formations of the Cambrian, Silurian and Devonian systems is briefer, the fullest account being reserved for those which are richest in minerals. Such are the Animikie, yielding silver ore; the Nipigon, in which native copper occurs; the Trenton, which produces petroleum and natural gas; and the Onondaga, which holds the beds of salt and gypsum.

Early sources of information are of limited range.

Special prominence given to the mineral bearing formations.

The classification of rocks which has been followed is that of the late Sir William Logan, the accomplished founder and for twenty-seven years the director of the Geological Survey of Canada. The geology of the mining districts is described in greater detail than that of other parts of the Province, and the geological relations of some of the principal mineral products are given as examples to illustrate their general character in the districts referred to. Additional facts on these subjects are mentioned in the Section on mines, especially on the occurrence of iron ores and phosphate of lime in the eastern part of the Province, and much new information available for these purposes has been collected by the Commission or supplied by the testimony of wit-

Classification of rocks and geology of the mining districts.

Sources of new information.

nesses. A supplementary account of the geology of the Sudbury district and of the mining operations there, brought down to the month of October, 1889, is given in the Appendix.

Mining operations on a business basis making slow progress.

A practical business basis has now been reached in the development of a number of our minerals, as for example in the production of salt, petroleum, phosphate, mica, cement, gypsum and building stones, and in the manufacture of brick, terra cotta, tile and sewer pipe. The silver and copper and nickel mines are also being worked with much skill and energy, and at the few locations where deep shafts have been sunk and galleries have been driven the existence of large ore bodies has been demonstrated. Iron mining has been intermittent hitherto, but its operations will doubtless assume a permanent place as a source of one of our largest mineral products when we shall have the steady demand of a home market to provide for, besides such foreign markets as we may be able to secure. It may also be confidently hoped that gold mining will become one of the established industries of the country, especially if attention be given to our refractory ores and should the economic treatment of them be satisfactorily solved.

Some losses of advantage specified.

The cost of mining machinery, much of which is not yet made in Canada, is a matter of common complaint with mine owners, as is also the high freight charges on machinery, supplies and ore; but these are losses of advantage which the enlightened good sense and liberality of our Governments and our railway companies may be expected to overcome. In no other way can a country add more directly to its wealth than by raising and utilising its minerals, assuming it to possess them in commercial quantities; for not only are manufacturing industries of many kinds created to treat them, but the raw material may itself be said to be created by the labor expended in searching for and mining it. Whatever lessens the cost of raising minerals and whatever facilitates their shipment to the best markets are the most obvious means of aiding the industry; and in so far as governments can remove burdens imposed by themselves, or reduce the cost of carriage by building or granting aid to build roads or railways, they to that extent make the success of mining operations possible.

Importance of the industry.

Explorers and prospectors are the pioneers of mining enterprise. They have already proven that our Province contains almost all of the economic minerals

in workable quantities except coal, and that it has vast possibilities of mineral wealth. Yet the tolls upon trade and the want of facilities for cheap transportation are a hindrance so serious to the employment of capital that a number of the most promising of known mineral properties are either lying idle or are being worked in the face of great odds. Encouragement of the industry, not its discouragement, is the office and duty of governments. Explorers, prospectors and miners deserve just consideration and liberal treatment. Mineral lands should be held for development, not for speculation. Mining enterprises should not be weighted with restrictions imposed by trade policies, and should as far as possible consistently with a fair consideration of the claims of all other interests of our country be secured the advantages of the home markets. Confidence in mining as a business should be established by yearly reports of progress made and work done. To instruct, to inform, to ascertain and publish facts, to lighten the industry, to enlighten the men employed in it and deal with them in a generous spirit—such, in the opinion of the Commissioners, is the true national policy for governments to pursue in promoting the development of our mineral resources.

Office and duty of governments in relation to the industry.

The evidence that Ontario possesses great mineral wealth is abundant, and is constantly accumulating. In the central and eastern counties are magnetic and hematitic iron ores, gold, galena, plumbago, arsenic, mica, fibrous serpentine, apatite, granite, marble and freestone. In the Sudbury district copper and nickel mines are being worked on a large scale. In the township of Denison rich specimens of gold-bearing quartz and extensive deposits of copper and nickel are found. Along the north shore of lake Huron, from the mouth of the French river to Sault Ste. Marie, gold and silver-bearing veins, iron, copper, galena and immense quarries of marble have been discovered. North of the height of land and extending towards James bay prospectors report a promising mineral region. North of lake Superior locations of gold, silver, copper, iron, galena, plumbago and zinc ores have been taken up, besides which there are inexhaustible supplies of granite, marble, serpentine and sandstone. West of Port Arthur is a silver district which, judging from the explorations already made, promises to be an argentiferous region of great richness. Beyond this district, to the northwest, are found veins of gold-bearing quartz and extensive ranges of magnetic iron ore, while to the southwest is believed to be a continuation of the Vermilion iron range of northern Minnesota. The partial examination already made inspires the hope that here will in time be developed an iron region of great value. Upon Sultana island and other islands in the Lake-of-the-Woods, and in the region adjacent to that lake, gold-bearing veins of

Mineral resources of the Province enumerated.

good promise have been discovered, and now that the question of title has been settled an early development of some of the properties may be looked for. But knowledge of the extent of our resources is necessarily imperfect. The area of the Province is vast, many districts have not been prospected at all, and therefore it may be reasonably presumed that only an inconsiderable portion of our mineral wealth is yet known to us.

But notwithstanding the extent and variety of our mineral resources, the statistics and tables presented in Section III show conclusively that in Ontario as well as elsewhere in the Dominion the mining industry is making slow progress. The value of the metallic and non-metallic mineral products of Canada for 1887 was $11,896,793, whereas the value of the same class of products in the United States in that year was $542,284,225, being nearly four times greater in the latter than in the former country per head of population.*

Relative production of Canada and the United States.

The United States is the principal customer of Canada for products of the mine, the value of our exports to that country for the seven fiscal years 1881 to 1887 being $18,567,710, while to all the rest of the world it was only $4,828,313. The value of the mineral exports of Ontario alone to the United States for the twenty fiscal years 1869 to 1888 was $14,329,330, and to all the rest of the world it was $3,342,894. These figures present in a striking light the natural commercial affinity which exists between the two great Anglo-Saxon divisions of the continent, and open a field of speculative enquiry as to what might have been the volume of the business if trade restrictions had not clogged its movement. The great store of ores and structural materials possessed by Canada and the transportation facilities by land and water for placing them upon the markets of the United States could not fail to have built up a trade of immense extent in mine and quarry products but for the duties which have served in a more or less perfect degree the purpose of preventing commercial intercourse.

Evidence of a natural commercial affinity between Canada and the United States.

Everywhere among men interested in mining operations, with the exception of those engaged in producing and refining petroleum, the Commissioners have met with expressions of an earnest desire to see the American markets opened to the admission of Canadian minerals free of duty upon terms equally fair to both countries. The amount of iron ore exported from Canada for

General desire for a larger and freer market.

* The table of the Canadian Geological Survey includes in the list of mineral products such articles as brick, charcoal, coke, fertilisers, glass and glassware, iron, iron ore, pottery ware, sewer pipe and tile, steel, sulphuric acid, terra cotta and tile, but as these are not embraced in the United States table their value is struck out of the Canadian total so that a fair comparison may be made. The statistics of 1888 show that the value of the metallic and non-metallic mineral products of Canada in that year was $12,048,421, and of the United States $584,550,676, being for the former country $151,628 and for the latter $42,266,451 more than the value of their respective products in 1887. See Appendix N.

the fiscal year 1888 was 13,544 tons, valued at $39,595, all but ten tons of which was mined in Ontario and exported to the United States. For the calendar year 1888 the shipment of iron ore from the lake Superior mines of Michigan, Wisconsin and Minnesota to lake Erie ports amounted to 5,023,279 long tons, or three hundred and seventy-five times as much as the entire export from Canada. This ore was worth $15,000,000 at the ports of shipment; about $6,000,000 was earned by the lake marine in its transportation to lake Erie ports, and a large but unknown amount by the railway companies over whose lines it was carried to furnaces at Pittsburg and elsewhere. For the calendar year 1889 the total output of the lake Superior mines was 7,292,754 tons, showing an increase in ten years of 5,917,063 tons, or 430 per cent. Ontario undoubtedly possesses large quantities of iron ore that might be delivered at all the furnaces of Ohio, Pennsylvania and New York as cheaply except for the duty as the ores of lake Superior, but her mines are almost absolutely idle.

The Ontario, Michigan, Wisconsin and Minnesota iron mines contrasted.

The increase in the world's production of iron from 1800 to 1888 has been nearly thirty-fold, it having grown from 825,000 tons in the former to 23,194,500 tons in the latter year. Of the product of 1888 Great Britain furnished 34 per cent. and the United States 28 per cent. The world's product of steel for the same year was 9,630,477 tons, and of this amount Great Britain furnished 35½ per cent. and the United States 30 per cent. Yet in the vast movement of industrial forces connected with the manufacture of iron and steel, over three-fifths of which centres in Great Britain and the United States, Canada has relatively an insignificant part, its total amount of wrought and puddled iron in the calendar year 1887 being only 31,501 tons and of steel 7,326 tons, while its make of pig iron in the fiscal year 1888-9 was only 24,822 tons.

Canada's insignificant share in the world's mineral and metallurgical production.

Our situation naturally suggests comparison between ourselves and our neighbors, and when we observe the rapid increase of mineral development in the United States, the great stream of capital flowing in upon the mining districts of the north and south, and the transformation of regions but lately almost uninhabited into scenes of industrial activity, the conclusion seems to be irresistible that if we could succeed in directing enterprise to our own mineral districts results of like kind would surely follow. More than one-half of the capital now invested in the mines and mineral properties of this Province is held by Americans, in spite of the repellent conditions imposed by trade policies upon both sides, and the extent to which it might further be attracted may be conceived by observing the growth of the industry in neighboring States.

Progress of the industry under free conditions.

The numerous complaints heard by the Commission respecting the mining laws of the Province made a careful enquiry into that subject necessary, and in addition to the information given and the suggestions offered by many witnesses the mining laws and regulations of the principal countries of the world have been examined and digests of them prepared, so that our own laws might be considered in the light of a wide experience. It does not appear to your Commissioners however that very radical changes are demanded. The provisions of the Act which relate to "mining claims" are found by experience to be unsuited to the occurrence of minerals in this Province, where no alluvial deposits of minerals are known to exist, and it does not appear that any properties are being secured under them. It is only in the provisions which relate to "mining locations" that changes in the law are felt to be desirable.

Mining laws of the Province.

The custom of terming a mining location a mine is itself misleading and mischievous, and unfortunately the terms are synonymous as defined by the Act. Mining men and capitalists have not infrequently met with disappointment in this Province by being brought to see a "mine" which has turned out to be only an undeveloped location, and to prevent the recurrence of such mistakes it is desirable that the term should be clearly and accurately defined.

Mining locations and mines used as synonymous terms.

The prospector and the explorer have special claims for consideration at the hands of the Government, for without their services many years may elapse before the mineral riches of the country are made known. They should have easy access to sources of information; geological and topographical maps of the territory they propose to examine should be placed in their hands if available; records of every transaction in mining locations should be open to their inspection, and they should be permitted to file and prove claims at the local agencies. The right of staking out claims might also be conceded in unsurveyed districts, under proper regulations. But in all cases it is desirable that proof of discovery of a mineral vein or deposit within the limits of the location applied for should be furnished before a claim is filed.

Prospectors and explorers.

The extent and number of locations which one person or company may claim or hold cannot easily be regulated in practice, and while in all cases the tenure of mineral lands should be subject to working conditions, it does not seem to your Commissioners that a wise or useful purpose can be served by a provision the effect of which would be to bar the profitable investment of capital. One strong company, if not hindered by a too narrow area, may employ more men and raise more minerals than half a dozen weaker concerns. But prospectors, explorers and miners deserve to be encouraged in the acquisition of locations of small area, and if their con-

Extent and number of locations, and working conditions.

veniences are better suited with the privilege of buying forty or even twenty acres instead of the present minimum of eighty acres, subject to working conditions, the country stands to gain rather than to lose by the sale of the smaller area.

Danger of forest fires in prospecting for minerals.

The Commissioners have been impressed with the danger which threatens one of the chief sources of revenue possessed by the Province in prospecting for minerals. They were struck with the appearance of many scenes of desolation where forest fires had swept over wide districts, leaving blackened tree trunks and fire-scorched wastes in the place of hills and valleys once covered with valuable timber. The loss to the Province from this cause has reached many millions of dollars within the last thirty years, and constant danger of further disaster attends the business of prospecting for minerals in the forest regions. Moss and leaves often conceal mineral veins, and in addition to the danger arising from carelessness there is reason to believe that unscrupulous persons sometimes set out fires and burn valuable tracts of timberland merely to facilitate their own work of search for minerals; and still oftener fires are started by the carelessness and even recklessness of sportsmen, tourists, missionaries, surveyors and others. This new danger to our forest wealth is one which may well engage the attention of the Government and the Legislature, and perhaps there is no simpler plan of keeping a check upon prospectors and explorers than to require each one to take out a license at the nearest land office, upon payment of a nominal fee, granting him permission to search for minerals within a district of defined boundaries.

Health and safety of miners, and collection of wages.

The Act contains no provision for the health and safety of miners, and although no law can ensure workmen against the occurrence of accidents or the effects of foul air, it is none the less necessary that every possible precaution for their health and safety should be taken. Neither is there any provision for the recovery of claims against employers, such as is found in the mining laws of many other countries, but it may be that the general statutes afford sufficient facilities to mine-workers in the collection of wages without special provision being made to suit their particular circumstances.

Mining and smelting of iron ores.

The mining industry may be carried on in a country, as it is in many sections of countries, without the smelting of metallic ores being undertaken. Great Britain imports large quantities of iron ores for her furnaces from Spain, Elba, Sweden and elsewhere, and almost the whole of the iron ores raised in the mines of the lake Superior ranges are shipped to furnaces in Chicago, Detroit, Cleveland, Pittsburg and other centres of iron-making in the United States. This practice has the advantage of enabling iron masters

to make mixtures of ores suitable for free smelting, as well as to produce the various grades of iron required by the manufacturers. But wherever the conditions are favorable, mining and smelting may be carried on most advantageously as the complements of each other. If sufficient supplies of fuel, flux and a suitable quality of ore are found close together, the best location for a furnace is at the mine, especially if there are facilities for shipping the product to market. It is unquestionably in a country's interest not only to smelt its own ores, but to refine and manufacture the metals, providing always that the various operations can be carried on economically and without taxing other interests indefinitely for their maintenance.

Growth and prosperity dependent on a knowledge of processes.

The history of the iron industry in Great Britain proves conclusively that its growth and prosperity have depended upon a knowledge of methods and processes. Towards the middle of the last century, before mineral fuel began to be used in blast furnaces, the total yearly make of pig iron in that country did not equal the production of one furnace of medium capacity at the present day. The industry was threatened with extinction, from which it was saved by the genius of Abraham Darby, who discovered the means of using bituminous coal as furnace fuel by converting it into coke. He worked out the problem in the sweat of a sleepless brain, and the narrative of his achievement is one of the most touching in the long story of the triumphs of man over matter. Darby's discovery was the beginning of Britain's career as the chief iron producing and iron manufacturing country of the world, and she owes that position to the service of processes and appliances begotten by the ingenuity of her sons. The cylindrical bellows of Smeaton, the steam-engine of Watt, the puddling process and the puddle rolls of Cort, the hot blast of Neilson, the steam hammer of Nasmyth, the various processes of Huntsman, Heath, Bessemer, Mushet, Siemens and others for the conversion of iron into steel, the utilisation of furnace gases and the improvements in furnace construction, mark every step in the progressive stages of the industry along its wonderful course. And it is mainly upon a knowledge of processes and skill in the use of them, conjoined with capital and prudent enterprise, that we must rely if a prosperous and stable iron industry is ever to be established in this country. We may begin with the best appliances, and with skill and capital we can start upon even terms with the iron men of the United States and Great Britain. But we should begin right—with experienced management, the best working plant, a sufficiency of capital, and not unmindful of the wants of the home market or our trade relations with other countries. The industry is of first class importance, and every proper means should be taken to secure its establishment in Ontario.

The prospect for making coke, anthracite, and charcoal pig iron in Ontario.

The course which a wise policy would naturally suggest is, to begin with whatever branch of the industry promises to give the largest profits and surest results. We have neither anthracite nor bituminous coal, and if one or other of these fuels were used it would require to be hauled long distances at a charge for freight dependent on our ability to furnish return cargoes. Besides, the margin of profit on coke and anthracite iron is never large, and the price is subject to frequent fluctuations as a consequence of the great capacity of British and American furnaces to produce supplies. With charcoal iron the case is different. The supply is limited, the demand is usually constant, superior quality causes it to be indispensable for certain purposes, and where ore, fuel and flux are found in proximity the margin of profit may be regarded as fairly liberal. From data presented in Section v, some of which have been furnished by metallurgists and others by iron masters or the managers of furnaces, it appears that the cost of producing charcoal iron in Ontario would be about $13.60 per long ton, the figures of ten estimates ranging from $9.08 for a hot blast furnace of 60 tons daily capacity to $18.50 for one of five tons capacity. There is no charcoal iron made in Ontario however, and all that is required for the manufacture of malleable castings is imported from the United States at a cost ranging from $26 to $38 per long ton according to quality—freight and duty paid. These prices ought to be considered as affording a liberal margin of profit on the cost of production, especially when the statement is made upon expert authority that a furnace of 9,000 tons yearly capacity would earn ten per cent. on a capital of $200,000 at a profit of $2.25 per ton of pig iron produced. Furnaces located at favorable points should be able to supply the home market with all the charcoal iron it wants, and, besides, keep out much of the poorer coke iron imported from other countries. The iron masters might even hope to make sales at good prices in the British and American markets, notwithstanding the freight charges on shipments to the one and the high duties which guard entrance to the other.

Mining and smelting of copper and nickel ores in the Sudbury district.

The most promising mineral works in the Province at present are the mining and smelting of copper and nickel ores in the vicinity of Sudbury. The Canadian Copper company began operations there in the latter part of 1886 and shafts were sunk on three separate locations, one of which had reached a depth of over 500 feet at the close of 1889. The ore body is proven to be very extensive, and large quantities have been raised at each of the mines. One water-jacketed furnace was set up by this company in 1888 and a second in 1889. Each has a capacity of smelting 120 tons of roasted ore per day, producing a matte which carries about 13 per cent. of nickel and 18 per cent. of copper. Computed upon the basis of work in 1889, the annual

yield will average 500 tons of refined nickel and 700 tons of refined copper per furnace, and for nickel alone this represents a market value of $500,000. During 1889 mining operations were commenced in the same district by the Dominion Mineral company of Montreal and Vivian & Co. of Swansea, Wales, the latter being owners of the largest copper smelting and refining works in the world. It is understood that furnaces are being erected by these companies at their respective mines, and that smelting operations will begin at an early day.

Alloys of nickel and steel.

The experiments recently carried on in England and Scotland with alloys of nickel and steel, to which reference is made in Section v, cause great interest to be attached to Ontario's deposits of nickeliferous ores. If the results already obtained are verified by further tests, and if the claims made for the alloys are fully borne out by practical application in the metallic arts, the importance of the inventions to this Province can hardly be over-estimated. The ranges already discovered in the region north of Georgian bay are more extensive than any which have been found elsewhere, and only a small portion of the formation carrying nickel and copper ores has yet been explored. It does not appear unlikely, indeed, that in spite of its unattractive aspect this may prove to be the most valuable portion of territory in the whole of Ontario, and your Commissioners venture to recommend to your Government the importance of carefully investigating its resources and encouraging by every legitimate means their development. The construction of new railway lines may be found necessary for opening new locations; and possibly a practicable scheme can be devised whereby not only the smelting of ores may be carried on upon a large scale, but also that the matte may be refined in the country instead of shipping it to distant places, and that our rich magnetic ores may be utilised in the manufacture of nickel steel.

Practical and scientific instruction in mining and metallurgy

In order that the mineral resources of the Province may be successfully and economically developed it is desirable that measures should be taken for the practical and scientific training of all who may engage in the industry. Prospectors and explorers are found to be very deficient in the kind of information which would enable them to prosecute their arduous labors to the best advantage, and your Commissioners recommend for that purpose the adoption of a scheme such as has been tried with gratifying results in the colony of New Zealand, and fully explained in Appendix L. But for the education of mining engineers and metallurgists a thorough system of instruction is called for, which can only be provided by establishing a School of Mines or enlarging the course of studies at the School of Practical Science in connection with the Provincial University. It is the opinion of your Com-

Bureau of mines, provincial museum and statistics.

missioners that if the duty of providing instruction of this character devolves upon the Government the obvious plan is to take advantage of the means which are available in the University courses of study, and to make such additions of instructors and appliances as may be necessary for a thorough equipment. And for economic and educational purposes of the first importance your Commissioners further recommend the establishing of a bureau of mines for the purpose of making a complete geological survey of the Province, and a museum of geology and mineralogy to represent its rock formations, minerals and metallurgical products, together with an efficient plan for the collection of yearly statistics of the mining and metallurgical industries of the Province, as indicated in Section VI of their Report herewith respectfully submitted for Your Honor's consideration.

(Signed) JOHN CHARLTON, Chairman.
ROBERT BELL.
WILLIAM COE.
WM. HAMILTON MERRITT.
ARCHIBALD BLUE, Secretary.

TORONTO, April, 1890.

SECTION I.

GEOLOGY OF ONTARIO, WITH SPECIAL REFERENCE TO ECONOMIC MINERALS.

The following sketch of the Geology of Ontario being intended for the use of persons who may not be familiar with the technical terms of geological science, the writer has endeavored to avoid these as much as possible, but where it has been necessary to employ them their meanings have been briefly given. For the same reason some elementary geological explanations have been incorporated, and a short glossary of technical words added at the end of the report, to save the non-scientific reader the trouble of referring to geological manuals or text-books. On the other hand, while this report will contain many new facts for geological readers, they must expect to find them stated in simple language. The limits imposed on the writer have permitted only a brief reference to each part of the subject, but it has been his endeavour to allot the space impartially to all. If, therefore, those who may be most interested in any one branch should find the description of it too short to satisfy them, they must consider the claims of all the others. It is hoped that, should the demand warrant it, a fuller report may be issued at a future time. Technical terms.

Owing to the uncertainty which has heretofore prevailed in reference to the northern boundary of the province, it will be necessary in attempting a geological description of Ontario to state at the outset how far we understand our territory to extend in that direction. For the purposes of description we will assume that the Albany river is the northern boundary all the way to the sea, and that a meridian line from James bay to the head of lake Temiscaming, and the Ottawa river thence to Point Fortune, constitute the eastern boundary. Bounds of the territory.

In order to facilitate our description and to prevent repetition we will here present a table, showing in their proper order all the divisions of the rocks of the province. [See next page.]

Igneous or eruptive rocks may be of any geological age, and those which occur in Ontario will be noticed in describing the systems or formations to which they are supposed to belong. In the list of the table the divisions of the rocks of Ontario are presented in their natural order of succession. It does not by any means represent the complete geological scale, comprising only the newest and some of the oldest systems. There is an enormous gap between the Post Tertiary and the Devonian, which in a complete section of the earth's crust would be filled up (in descending order) with the Tertiary, Cretaceous, Triassic, Permian and Carboniferous. The whole of the Gaps in the System.

DIVISIONS OF THE ROCKS OF ONTARIO.

In descending order.

SYSTEM.	
	Recent.
Post Tertiary.	Soils, Peat, Shell-marl.
	Lacustrine and Fluviatile Clays, Sands, etc.
	Pleistocene.
	Saugeen Clay, Artemesia Gravel, Algoma Sand.
	Sand, Gravel and Shingle of the country north of the Great Lakes.
	Erie Clay, Calcareous and Non-calcareous Clays north of the Great Lakes.
	Boulder-clay, Drift or Till.
	Palæozoic.
Devonian	Chemung and Portage.
	Hamilton Formation.
	Corniferous Formation.
	Oriskany Formation.
Silurian	Lower Helderberg Formation.
	Onondaga Formation.
	Guelph Formation.
	Niagara Formation.
	Clinton Formation.
	Medina and Oneida Formation.
	Utica Formation.
	Trenton Formation.
	Black River and Birds-eye Formation.
	Chazy Formation.
	Calciferous Formation.
Cambrian......	Potsdam Formation.
	Nipigon Formation.
	Animikie Formation.
	Azoic or Archæan.
Huronian......	Upper (?) Huronian Formation.
	Lower (?) Huronian Formation.
Laurentian ...	Upper Laurentian Formation.
	Lower Laurentian Formation.

geological scale is not found in any one region of the surface of the earth, but the order of succession has been ascertained by tracing the connection of one with another, principally by the aid of the fossils or organic remains which they contain. Between the time of the deposition of the highest or newest of our Devonian rocks and the oldest of the Post Tertiary a vast interval elapsed, during which this part of the world may have been dry land and little or nothing may have been deposited upon it. But it is far more likely that rocks of some, at least, of the systems now wanting were laid down which have long since decayed and disappeared through the action of denuding agencies; while elsewhere the conditions have been more favorable for the preservation of some of them in one country and others in another.

In describing the rock-formations of Ontario we propose to begin at the bottom of the scale, or with the oldest, and proceed in the natural order or that of their age. First, however, a few words may be necessary in regard to the terms employed and the names of the divisions themselves. Geological divisions.

The term 'system' in geology is used to designate great series of strata characterised by such similarity that they may 'stand together,' as the word implies. In the Azoic or Archæan division the rocks themselves comprising a system have certain points of resemblance in common, while among the fossiliferous strata each system is recognised by the remains of some prevailing forms of animal or plant life. The systems are intermediate in comprehensiveness between the periods or ages and the formations, each system usually comprising several formations. System.

The 'formation' constitutes, as it were, the unit in the geological classification or grouping of the rocks. Among fossiliferous rocks each formation comprises strata which may be distinguished from all others by their organic forms, most of which are peculiar to such formation. Non-fossiliferous formations comprise rocks which have a recognised position in the scale, or which possess some strong points of resemblance sufficient to distinguish them; or they consist of rocks which have been formed under similar conditions and, as far as can be ascertained, at about the same time. Unfortunately the term formation has been employed by some geologists rather loosely, or without a uniform and definite signification, and of late years an attempt is being made to give it a more extended meaning, by which it would take the place of the well-established term 'system.' Formation.

The word 'group,' which is so often used in geological language, is another which does not yet enjoy a universally established meaning. Heretofore Canadian geologists have been accustomed to use it as intermediate in comprehensiveness between system and formation. Thus we spoke of the St. John group, the Quebec group, the Trenton group, the Anticosti group, each embracing a number of formations. At the present time some European geologists are seeking to give the term a larger signification, equivalent to system, or even period. Group.

But the word which has been used most loosely of all in geological language is 'series,' which is still made to do duty wherever there is any uncertainty as to the rank of any set of rocks. Series.

Ontario names for Systems and Formations.

In regard to the proper names for the various divisions of our rocks the late Sir William Logan, when he undertook the geological survey of the province of Canada in 1842, wisely foresaw the advantage of adopting the names already in use in the state of New York, adjoining us. In this way there was no confusion, and everyone understood without further explanation the positions of our various formations as described by Logan under these names. Geological formations are distributed in the crust of the earth without reference to national boundaries, and true geologists are the most cosmopolitan of men, the whole earth being their field of research, as the very name 'geology' implies. The New York state and other American geologists had adopted the names for the systems which had been given in England, such as Cambrian, Silurian, Devonian, Carboniferous, etc., but as the subdivisions or formations in America could not be closely correlated with those of England, local names had to be adopted. Most of the formations of Upper and Lower Canada were found to be continuous with those of the adjoining states, so that the names for these were applicable on both sides of the international boundary line. In a few cases, such as that of the Hamilton formation, named after the village of Hamilton in Madison county, N.Y., some misconception has arisen from the supposition that the name is derived from our own city of Hamilton. Professor Chapman has proposed the alternative name Lambton formation, as it occurs chiefly in Lambton county in Ontario. One of our Ontario formations, the Guelph, is not represented in the state of New York, and the name which it bears was proposed for it in 1861 by Dr. Bell, of the Geological Survey, after the city of Guelph, which is built upon it. The name Nipigon was proposed by the same gentleman for one of the lake Superior formations, on account of its local importance and peculiarities, and because of a doubt as to its equivalency with any of the formations which had been already named.

The Saugeen Clay, Artemesia Gravel, Algoma Sand and Erie Clay, the names of which were also proposed by Dr. Bell, and adopted by Sir William Logan in the 'Geology of Canada,' constitute formations which are distinguished mainly by the characters of the deposits themselves, although organic remains have been found in some of them. The name Animikie, for an important formation on the north-west shore of lake Superior, was proposed by Dr. T. Sterry Hunt in 1871, two days before Dr. Bell had suggested Lower Nipigon for the same formation, and the former term has been retained. The terms Huronian and Laurentian were given by Logan and Hunt early in the history of the Geological Survey, and have been followed by geologists, not only for Canada, but in all quarters of the globe where rocks of corresponding systems exist. About the same time the name 'Lawrentian' was suggested by another geologist for the Post Tertiary clays and sands of Vermont and Lower Canada, but it was soon after dropped, these deposits becoming known as the Champlain clays and sands.

Other names for some of the systems and formations represented in Ontario have been more or less employed by geologists, and these will be mentioned in the more detailed descriptions to follow; but in order to preserve simplicity they have not been given in the table.

GEOGRAPHICAL DISTRIBUTION.

Before proceeding with an account of the geological or lithological nature of each of our formations and of their economic minerals, we shall give a brief outline of the leading geographical features of the principal divisions. Along with the descriptions of the individual formations, the areas which they severally occupy will also be given in sufficient detail. The Recent and Pleistocene clays, sands, etc., are called superficial deposits, and the older and harder rocks below them in Ontario may be termed the fundamental rocks. The ordinary geological map of Canada represents the latter only, as if the superficial deposits did not exist. It would be difficult to show both at the same time, as these deposits are spread independently over all the older rocks alike. A separate map for the superficial deposits therefore became necessary, and such a map was prepared by Dr. Bell and published in the atlas which accompanied the Geology of Canada in 1863.

Geographical features of geological divisions.

In order to form a clear idea of the general features of the geology of Ontario it will be desirable in our introductory remarks to go beyond the immediate borders of the province, and consider for a moment some points bearing on the structure of the continent.

Structure of the continent.

The most northerly section of Ontario, or that bordering on the lower part of the Albany river and James bay, resembles the most southerly portion, or the peninsula between lake Huron and the lower lakes, in being underlaid by almost flat-lying Silurian and Devonian rocks, while the great intermediate tract is occupied by a part of the Azoic area which stretches to the Arctic regions. Most of this tract consists of Laurentian gneiss, but between lake Huron and James bay there is a very large district of Huronian rocks which are of much importance an account of the economic minerals they contain. The Palæozoic rocks coming within the province in the northern or James bay region occupy an area almost as great as those of the southern peninsula of the province, while the whole extent of these rocks on the west side of James bay is much greater. In both regions they are quite undisturbed, except in a few local cases, and remain in the almost horizontal positions in which they were originally deposited at the bottom of the sea. This is owing to the fact that they have been protected from movement by the massive and unyielding Azoic rocks that form the foundations on which they lie.

The Hudson Bay slope.

This protection has not been extended to the Palæozoic rocks of eastern Pennsylvania and the region lying east of a line running up the Hudson river, through lake Champlain, and thence to the city of Quebec and down the lower St. Lawrence. To the east of this line a mighty force, supposed to be due to the gradual shrinking of the earth, has acted for ages from a south-easterly direction, and has caused the great undulations in the strata that now form the Appalachians, the Green and White mountains and the Notre Dame range, extending into the Gaspé peninsula. It has also produced great dislocations or faults and overturnings of the strata. The Palæozoic rocks of both the northern and southern extremities of Ontario having been sheltered from this force, their structure and geographical distribution are simple and have been worked out with comparative ease.

Palæozoic strata of the east.

Foldings of the Azoic rocks.

But the Azoic rocks are highly disturbed, and much more folded and contorted than the Palæozoic strata of the east. As a rule the foldings have been pressed together so completely that their anticlinals and synclinals have taken the form of sharp A's and V's, and the normal position of the stratification is usually more nearly vertical than horizontal. The lateral pressure which caused this has probably been due also to the shrinking of the whole globe. Besides folding the Azoic strata in the manner described, this pressure has developed in them a slaty cleavage, whenever their nature would permit of it, and has also aided in producing their prevailing crystalline texture. But all this took place before the formation of the Palæozoic strata, which rest almost horizontally upon the truncated edges of the crystalline rocks.

The Palæozoic region of southern Ontario.

The unaltered fossiliferous beds of southern Ontario form part of a great Palæozoic region which stretches over most of the northern states, while those of the northern extremity of the province appear from their fossil evidence to have been deposited in a part of the ancient sea which must have been separated from the main body much as Hudson bay is now separated from the Atlantic ocean.

THE AZOIC PERIOD.

Azoic rocks of Ontario.

This great division is so called because, as yet, no trace of either animal or plant life has been found in it. It is also termed the Archæan period or age. In Ontario the rocks which belong to it may be grouped under the Laurentian and the Huronian systems, although other divisions have from time to time been proposed for some of them. These two divisions are considered sufficient by many geologists for the Azoic rocks of the whole world. Without taking local peculiarities into consideration, the primitive rocks of all countries may be classified under one or other of these great systems, even if subordinate divisions should be found convenient in some localities. The characters and proportions of the different rocks which make up the Laurentian and Huronian are naturally found to vary much in different regions, although they are everywhere essentially the same systems and retain the same relative positions, representing similar conditions in the geological history of the globe. They form the foundations of the crust of the earth as far as we can observe or penetrate it, and are easily separable from any rocks lying above them. Their crystalline characters and generally disturbed condition are their distinguishing features. At the same time it is true that, in some instances, newer rocks have been so altered locally or even over considerable tracts as to resemble the Azoic, but we generally find some means of distinguishing between them. In Canada and the United States the Laurentian and Huronian are usually intimately associated, but their lithological features, or the internal characters which distinguish rocks from one another, are sufficiently distinct to separate them. As they are for the most part included in one great area they must be to some extent described together.

Geographical distribution of Azoic rocks.

The Azoic rocks of Canada have been represented as extending from the region of the great lakes in the form of two arms, one stretching northeastward to the Atlantic coast of the Labrador peninsula and the other northwestward to the Arctic sea, east of the mouth of the Mackenzie river, the

intervening space being filled up with Palæozoic rocks. Further light on the subject has, however, shown that the geographical outline of these rocks takes the form, approximately, of an immense ellipse which includes the north-eastern part of the continent, Baffinland, Greenland and many of the islands of the frozen sea. It comprises the whole of the Labrador peninsula, measuring a thousand miles each way. On the other side its boundary runs, with a westward curve, from lake Winnipeg to Coronation gulf, another thousand miles, with a spur towards the mouth of Mackenzie river. The Palæozoic rocks of Hudson bay form a sort of broken fringe around that inland sea, and a belt of them extends thence northward across some of the islands to the Arctic ocean. The geographical depression of Hudson bay, to which the rivers flow from all sides, forms the central drainage basin of this Azoic area of North America, and its origin is of very ancient geological date. At various periods of the earth's history it was probably covered by waters more or less separated from the outer ocean, and the newer rocks in its centre were deposited from these in the same way that deposits are forming in the bottom of the bay at the present time.

Nucleus of the continent.

Although the superficial continuity of the Azoic region just described is broken in many places by channels of the sea, and by outlying patches of Palæozoic rocks, it may be regarded as practically one area of compact outline, and it forms the nucleus upon which the rest of the continent has been built. On the east it falls abruptly into the deep ocean, but on its landward sides it is flanked by the formations which have been successively deposited around it. The further we recede from it the newer the rocks become, till in one direction we reach the Rocky mountains, which have broken up through a vast thickness of these succeeding strata.

As a rule the Huronian rocks are less contorted or corrugated on the small scale than the Laurentian, but on the large scale they partake of the same foldings which have affected the latter. At one time they were supposed to be less abruptly bent into anticlinal and synclinal forms, but this appears to have been a misconception, due to the fact that some of the highest beds happened to have been first studied in a district that is less disturbed than the average. In other localities some of the Laurentian rocks are quite as little disturbed.

A region of mixed Laurentian and Huronian rocks.

The greater part of the mixed Laurentian and Huronian region belongs to the former, and of it the Lower Laurentian is the prevailing type. As represented on a map, the Huronian occurs in the midst of the Laurentian in the form of more or less completely separated areas, or with straggling connections between them. They seem to be in a manner interwoven with the Laurentian as basins or troughs more or less elongated, and as tracts of angular and other forms filling spaces between great nuclei or rounded areas of Laurentian rocks. Patches of Huronian strata of comparatively small size are numerous throughout this vast Azoic region of the north-eastern part of the continent, and in addition to these there are a few of great extent. One of them is on the north-west side of Hudson bay, and appears to stretch far inland. Another lies to the north and north-east of lake Huron, reaching from the east end of lake Superior

almost to lake Mistassini, a distance of 600 miles. In Wisconsin and Michigan also considerable areas exist, and in the country between lake Superior and lake Winnipeg Huronian rocks of many different basins are largely mixed with the Laurentian, constituting perhaps one-third of the whole area. In the country between the northern extremity of lake Winnipeg and Hudson bay the writer has described a Huronian trough 180 miles in length, and Mr. A. S. Cochrane found these rocks between the Saskatchewan and Churchill rivers and largely developed on the north side of lake Athabasca.

THE LAURENTIAN SYSTEM.

We have given the above brief account of the relations of the Laurentian and Huronian systems to each other, and of the distribution of the two in north-eastern America, in order that the reader may the better understand what is to follow in regard to the rocks that occupy the greater part of Ontario as now extended. The country formed by these two systems is sometimes referred to as the Laurentian region, but it is more correctly called the Azoic or Archæan when areas of both classes of rock are included. We shall now proceed with a short description of the Laurentian alone.

Lower Laurentian or Primitive Gneiss series.

As indicated in the table already given, the Laurentian system has been divided into two formations, the lower of which is sometimes also called the Primitive Gneiss series. The differences between them can be best pointed out after having described the Lower Laurentian. Both formations give rise to the same kind of country which is so familiar to all Canadians. As a rule it is hilly, but not greatly elevated above the sea, and full of lakes. Within the regions which have been sufficiently explored to speak of with some degree of certainty these amount literally to tens of thousands, and occupy a very considerable proportion of the whole surface, estimated in some sections at one-third and even one-half of the whole area. The cause of the existence of these lakes will be explained further on. The high northern part of the coast range of eastern Labrador has not been glaciated, but almost everywhere else there are unmistakable signs of this phenomenon. This has given rise to the peculiarity of the Laurentian country which Sir William Logan has so graphically described as mammillated. This vast hilly country, however, cannot properly be called "the Laurentian range."

LOWER LAURENTIAN FORMATION.

Character of the Lower Laurentian.

The Lower Laurentian consists essentially of gneiss. In some localities its foliated or stratiform character is obscure, and it may be called granitic or syenitic. The distinctly banded varieties differ from one another considerably in the proportions of their constituents. True gneiss is defined by lithologists to consist of quartz, felspar (orthoclase) and mica, but most of the gneisses of both the Lower and Upper Laurentian contain hornblende, often in large proportion. These would be called hornblendic or syenitic gneisses. The proportions of these minerals vary constantly, and it is seldom that there is any great thickness having the same composition.

Gneissoid rocks.

One layer may consist chiefly of felspar and quartz, the next may contain much hornblende or mica in addition, while a third may consist

largely of any one of these alone. These minerals, in fact, enter into the composition of all the gneissoid rocks in every conceivable proportion. It is easy for the mere lithologist to select typical varieties of rocks in a good cabinet collection, but in the case of the gneissoid rocks it is impossible for the field geologist to recognise these distinctions on a large scale. In the Lower Laurentian hornblende is almost as generally diffused as the felspar, quartz and mica. It sometimes occurs as bands consisting almost exclusively of this mineral in both the lower and upper divisions. In the latter it has been noticed particularly in proximity to the limestone bands and the iron ore deposits. The Laurentian hornblende rocks are usually blacker and more coarsely crystalline than those of the Huronian system.

The prevailing colors of the Lower Laurentian gneisses are greyish and reddish, from very light to very dark shades, depending partly on the colors and partly on the proportions of the different constituents. The felspar (orthoclase) is white, grey and red, or sometimes yellowish or greenish ; the quartz is white to grey, and the mica and hornblende black, or very dark green or brown. These rocks are generally distinctly foliated, or show a lamination or parallelism in the arrangement of their constituent minerals easily traceable by their colors. Where these are very distinct and the layers continuous and close together, the rock in cross-section is described as ribboned ; where the layers are further apart it is called banded. But the bars are often broken into a series of tapering dashes which pass below or above each other, or with an interlocking or "dovetail" arrangement, or the bars may be connected by thin streaks or rows of dots. Even where the tendency to parallelism in the texture of gneiss is not conspicuous, from the want of contrast in colors, it can always be seen on close inspection, and this kind of structure or "grain," like that of wood, is what distinguishes gneiss from granite, the latter having no such parallelism in the arrangement of its constituent minerals. On the supposition that this structure of gneiss, even when the parallel bands of different kinds are quite thick, may be accounted for in other ways than by stratification due to the action of water, some geologists hesitate to speak of it as stratification or bedding, notwithstanding its apparent identity with it. Color and form of gneiss rocks.

As a rule in Canada the exposed surfaces of the gneiss rocks show little sign of decay, on account of their having been worn down by glaciers in comparatively recent geological times, and they are extremely massive. When broken up, as by blasting, they fracture almost impartially in all directions, or show only a slight tendency to cleavage along the plane of their foliation. This foliation in the gneisses of the Lower Laurentian is usually contorted or bent in various directions on the small scale, and any differences in their composition or colour do not appear to be sufficiently persistent to trace them far in any direction on the ground ; in other words, they are not so sufficiently differentiated into great bands of distinct kinds as to enable them to be shown on a map of moderate scale, as is often the case with the gneisses and other rocks of the Upper Laurentian. Still, in those areas which have been most examined, a general tendency has been observed to strike more nearly in a north-east and south-west direction than in any other. In eastern Labrador, Foliation and strike.

and also in Baffinland, the larger mountain ridges run north-westward, but it has not been ascertained that this is the direction of the strike of the gneiss in those regions. The monotonous grey and red massive and contorted gneiss above described prevails throughout the vast Lower Laurentian region stretching from the great lakes of the St. Lawrence to Hudson bay and thence to lake Winnipeg, as well as in the western and most of the southern parts of the Labrador peninsula.

Dykes and veins in the Laurentian system.

In some districts the Laurentian rocks are cut by dykes of greenstone or trap, some of them very large and affecting the geographical features. Rivers or long narrow lakes sometimes lie upon the courses of dykes which had become decomposed and yielded to glacial action, while falls and rapids occur where hard dykes cross the courses of streams. Both the Lower and Upper Laurentian formations are cut by veins of two classes, the first being much more ancient than the second. The former, which are numerous, are, as it were, fused into or amalgamated with the country rock and are composed of the same minerals. In some cases the gangue is almost entirely felspar, in others quartz, but oftener the two minerals are mixed together and a little mica or hornblende is added. The larger veins of this class are very coarsely crystalline; the smaller ones have a tendency to branch off or become reticulated. Although the division between them and the wall-rock is distinctly defined by the contrast of color, there is no actual separation between them, the two breaking like one rock. Metallic ores have not been found in these veins in economic quantities.

Minerals in the veins.

Veins of this class may be seen in almost any locality where the gneisses are exposed. The veins of the second class are not so common, and have been formed long subsequent to those of the first class. Their gangue, which is frequently calcspar, separates easily from the wall rock, and is apt to contain galena, copper and iron pyrites and zinc blende; but these minerals, like the veinstones themselves, have perhaps been derived from rocks resting on the gneiss, or which rested upon it at some former period when these veins were formed but which has since been removed by denudation. The lead-bearing veins of the counties of Frontenac and Leeds and those north of the Canadian Pacific railway opposite the head of Black bay, lake Superior, are examples of the second class. With the exception of the contents of veins of this class and the coarsely crystalline felspar and quartz of those of the first class, no minerals of economic value are known to occur in Canada in the Lower Laurentian formation or primitive gneiss series above described.

UPPER LAURENTIAN FORMATION.

Classification of the series.

Under this name Sir William Logan described a series of massive labradorite and anorthosite rocks, such as those north of Montreal, in the region of the upper Saugenay, on the north side of the St. Lawrence just below Quebec, and on the Moisie river; and similar rocks are found on the west side of lake Champlain. He thought that they might be above and unconformable to the gneisses, or interstratified gneisses and limestones nearest to them. Professor James Hall agrees with Logan's view. Dr. Selwyn thinks they may be interstratified with the gneisses and limestones. In Parry Sound

district, where the writer found anorthosite rocks, they are interstratified with gneisses, etc., with which limestones, similar to those of the county of Argenteuil, in Quebec, are also associated. It would appear from the writer's observations over the vast Laurentian regions of Canada that for the present, at least, it will be convenient to designate as Upper Laurentian both the anorthosite rocks such as those above referred to, and the limestone-bearing series such as that which was so carefully worked out by Sir William Logan in the county of Argenteuil and sometimes called the Grenville series, as there are good reasons for this classification, and it is the most convenient one in the present state of our knowledge. In the counties of Terrebonne, Montcalm and Joliette, in Quebec, rocks similar to the Grenville series have been found since Logan's time to be interstratified with anorthosite gneisses. Dr. Selwyn regards the more massive anorthosites or labradorite rocks of Argenteuil, Terrebonne, etc., as probably of igneous origin, and as in some way incorporated with the adjacent limestone-bearing series. Professor Hall, the state geologist of New York, considers the similar rocks, which are largely developed on the west side of lake Champlain, to overlie the adjoining gneisses unconformably. Both views may be correct. It is highly probable that volcanic activity went on more energetically and on a grander scale in these early days of the earth's history than now, and great outbursts of basic matter, such as these anorthosites, were of frequent occurrence in Laurentian times. After spreading out upon the surface of the earth or on the bottom of the sea, some of them became incorporated in a conformable manner with the contemporaneous deposits, while others may have flowed over pre-existing rocks which were even then disturbed. The latter would form the unconformable masses of Logan and Hall.

Mineral bearing character of the upper series.

There may be a general want of conformity between the primitive gneisses of the Lower Laurentian and all the rocks of the upper series which succeed them, including both the massive anorthosites and the limestones with their accompanying gneisses. There is a considerable change of character in passing from the one to the other, and this is important from an economic point of view. While the Lower Laurentian is apparently barren of metallic ores, the upper series as above defined contains a considerable variety of them. In addition to the presence of the limestone and dolomite bands and the anorthosite rocks which constitute their leading distinguishing features, the Upper Laurentian is characterised by the occurrence of iron ores, graphite, apatite, pyroxene and hypersthene rocks, quartzite and argillite bands, granite, syenite and porphyry, and perhaps conglomerates. Besides the above differences, Mr. W. C. Willimott enumerates the following sixty-one species of minerals as found more or less commonly distributed in these rocks, few or none of which have yet been detected in the Lower Laurentian :

Achroite.
Actinolite.
Agate.
Allanite.
Amazon-stone.
Anorthite.
Aphrodite.
Aventurine felspar.
Axinite.
Barite.
Beryl.
Bismuthinite.
Bismuth carbonite.
Blende.
Bornite.
Celestite.

Chabazite.	Oligoclase.
Chrondodite.	Peristerite.
Chrome garnet.	Perthite.
Chromite.	Picrolite.
Chrysotile.	Pyrallolite.
Corundum (Hunt).	Pyroxene (and its varieties, sahlite, diopside and cocolite).
Essonite.	Pyrrhotite.
Fluorite.	Rutile.
Gold.	Samarskite.
Graphite.	Scapolite.
Heulandite.	Serpentine.
Idocrase.	Steatite.
Jasper.	Sphene.
Labradorite.	Spinel.
Limonite.	Stilbite.
Malachite.	Talc.
Microcline.	Meneghinite.
Mispickel.	Tourmaline.
Molybdenite.	Tremolite.
Molybdite.	Uranite.
Monazite.	Zircon.
Mountain cork.	Zoisite.
Nickeliferous pyrites.	

Boundary of the Upper Laurentian series.

No attempt has yet been made to mark the geographical division between the Lower and Upper Laurentian as above defined. But if we draw a line from near the north shore of lake Nipissing north-eastward, nearly parallel to the St. Lawrence, and at an average distance of about 150 miles from it, we may not be far from its position, for the region between lake Huron and the gulf of St. Lawrence.

Supposed aqueous origin of gneiss in the Upper Laurentian.

Notwithstanding the various differences which distinguish the Upper from the Lower Laurentian, there is often a close resemblance in the gneisses of the one to those of the other. In fact it would often be difficult to distinguish between hand specimens taken from the two series. This fact should be borne in mind in considering the origin of gneisses in general. As the balance of evidence is strongly in favor of the aqueous theory of the origin of at least part of the Upper Laurentian, this lends support to the view that even the primitive gneisses may have been formed by the action of water during some early condition of the earth, of which we can form but little conception judging by the later stages of its history. Minute globules of water have been found by microscopic examination in the centres of crystalline grains forming gneiss, and more or less water may be driven out of these rocks by means of heat.

The Eozoon Canadense a scientific myth.

At one time some geologists alleged that they had detected an organic form, to which they gave the name of "Eozoon," in the Upper Laurentian rocks; but on investigation by others the hypothetical discovery was not endorsed, and the organic nature of the supposed fossil has been repudiated by nearly all scientists. It is believed that organic life not only did not begin on our planet in Laurentian times, but that for ages afterwards the earth was not fitted for its reception. Forms like the branching structures which are the portions of the so-called eozoon, and which are claimed to have a resemblance to organic forms, are assumed by a great variety of minerals, but in the case of eozoon these forms are unlike any organic structure in the fact that they are all different one from another.

It has been asserted that the limestones, iron ores, graphite and apatite are also evidence of the existence of animals or plants in Laurentian times. Such an argument, however, appears to have no good foundation. The limestones have been carefully examined by numerous geologists over immense regions during the last forty or fifty years and have yielded no evidence to support this view, but rather the opposite, namely, that they are of chemical origin. The iron ores occur in greater masses than any of those deposits which appear to have been aided by organisms in their formation, and, besides, their modes of occurrence are opposed to any theory of this kind. The graphite and apatite occur principally as vein matter. The largest deposits of the latter have been derived from the pyroxene rocks, which are evidently of igneous origin. Apatite is a common constitutent of traps and granites of all kinds, and is widely diffused in small grains even in gneiss. The argument as to its organic origin is based on the fact that phosphate of lime is the principal constitutent of the bones of vertebrate animals; but, in the natural order of things, the phosphate must have existed first and the vertebrate animals later on. The converse of this is absurd. There is no evidence to show that phosphorus, carbon, iron and calcium did not enter into the original constitution of the earth as well as the other elements.

Origin of Laurentian limestones and iron ores.

ORIGIN OF LAURENTIAN ROCKS.

It it rather singular that the numerous minerals above referred to should appear for the first time in the upper Laurentian rocks, and this fact also suggests many questions as to their origin and mode of formation. One of the most remarkable features of the Lower Laurentian is the general uniformity in composition and character of the gneiss over so vast an area, almost semi-continental in extent. The comparatively fine-grained and even texture which prevails everywhere might not have been looked for in these ancient rocks, which have had such ample time to become coarsely crystalline or to exhibit local variations. These circumstances seem to prove a uniformity of origin as well as of the condition of the surface of the earth at the time they were formed, as similar rocks also crop up from under all others in various parts of the world.

Origin and mode of formation of the Laurentian rocks.

Without stopping to consider the great differences in the various classes of rocks belonging to the Upper Laurentian, some geologists have suggested a general igneous origin for the whole of them. On this hypothesis it is supposed that these rocks may be compared to slags which have formed on the surface of a molten mass, and that instead of cooling quietly and homogeneously some force has acted on them, giving a sort of flow-structure such as may be seen in slags which have run from a blast furnace. It is difficult, however, to conceive how such a minute and even structure could have extended through so great a thickness, the depth of which is unknown, but which must amount to many miles in the Lower Laurentian alone. Others attempt to account for the stratiform condition of the Laurentian rocks by the agency of pressure, but it is impossible to imagine that this force could separate the rocks into immense bands of different kinds such as those of the Upper Laurentian, which differ from each other as much and on as large a scale as do the rocks of any of the later systems. When we consider the great variety and thick-

Their supposed igneous origin.

ness of the Upper Laurentian, amounting to 50,000 feet or more, and including great bands of different sorts of limestones, dolomites and gneisses, and smaller ones of schists or quartzites, argillites, bedded iron ores, etc., the conclusion appears irresistible that they are, principally at least, altered sedimentary strata, as Logan so emphatically stated after having studied them for years in the field. The circumstance that many varieties of the Upper Laurentian gneisses are undistinguishable from those of the lower series would indicate that, like the latter, they have been formed during a primitive and probably heated condition of the earth. Sir William Logan's painstaking investigations in the county of Argenteuil and other localities in Quebec show the various thick belts which he traced out in all their sinuosities to conform in their geographical distribution to the structural laws of ordinary stratified rocks, where these have been thrown into undulations, or anticlinals and synclinals, and afterwards denuded.

Altered sedimentary strata.

The Upper Laurentian rocks seem to be much more limited in geographical extent than the lower. Including both the anorthosite and the limestone-bearing portions under this designation as above described, the series, as already stated, may be said to extend from the lower St. Lawrence westward to lake Huron and northward in some places for about 150 miles, but beyond that distance it has not been recognised. It is largely developed between the Ottawa river and the Palæozoic region north of lake Ontario, and again between Georgian bay and lake Nipissing. Some of the rocks of the Hastings and Lanark region which were formerly included in this series are now believed by some to belong rather to the Huronian.

Extent of the Upper Laurentian series.

Anorthosite or labradorite rocks are extensively developed in eastern Labrador, and there are indications in that region of iron and other ores as well as of non-metallic minerals indicative of the upper series. On the shores of some parts of Hudson straits the gneisses are divided into great bands with distinctive characters, and here iron ore, iron pyrites, graphite, sphene, sheet mica and some of the other minerals of this series are found, and in one place the writer noticed a loose piece of crystalline limestone of one of the varieties peculiar to the Upper Laurentian.

Labradorite rocks.

The Laurentian and to an almost equal extent the Huronian districts of Canada are characterised by great numbers of lakes of all sizes, and mostly of very irregular forms. Throughout these vast but little explored regions they exist in hundreds of thousands. It is estimated that, in some sections of this land of lakes, from one third to one-half of the entire area is water. Some of them are one hundred miles and upwards in length, and many measure from twenty to fifty miles. They generally show a tendency to run in chains or groups in different courses, and thus they afford a means of travelling by canoe in almost any direction. They are nearly all rock-basins, and on the water-sheds they not infrequently have outlets in opposite directions, sending the water down either slope. One of the most remarkable examples of this phenomenon in Ontario occurs on the divide to the north-east of lake Nipigon, where rivers of equal size flow from each end of Summit lake, one into Hudson bay and the other into the St. Lawrence. Both streams are uninterruptedly navigable by canoes for some distance after leav-

A land of lakes.

Lakes with double outlets.

ing the lake, so that travellers may here cross the water-shed by continuous navigation.* Temagami lake, north of lake Nipissing, one of the most picturesque lakes in America and measuring fifty miles each way, is another striking example of this kind. Its northern outlet flows into the Ottawa by way of the Montreal river and its southern by Sturgeon and French rivers into the St. Lawrence. What is still more remarkable, this lake, as shown by Dr. Bell's surveys, had in former times an eastern outlet to the Ottawa and a western to the St. Lawrence, and if its level were now raised only a few feet these channels would again help to drain it, so that it might have four outlets flowing towards all the cardinal points of the compass, the two pairs of opposite discharges being each about fifty miles apart. No fewer than eight examples of lakes with double outlets are known among the upper branches of the Ottawa.

Ontario a group of islands.

The question naturally arises—What was the probable origin of these innumerable lakes? Their formation and that of the boulder clay, and the existence of the surface boulders consisting of primitive rocks which are so abundant over the Azoic regions and often beyond them, as well as the rounding, fluting and grooving of the rocks which may be seen almost anywhere on the removal of their superficial coverings, are all mutually related phenomena. Without going into details, it may be stated that before the beginning of the glacial epoch the surface had been subjected to a long period of decay. Under the influence of water and other decomposing agencies the crystalline rocks became softened to a great depth, as may now be seen in similar rocks in South America and elsewhere. One of the best examples of this in Canada is to be found in the north-eastern part of the Labrador peninsula, where the same gneisses, etc., which in these latitudes we are accustomed to see as hard rounded hills and knobs, form pointed hills and ridges in a soft and decayed condition so unlike the former as to be quite unrecognisable at first sight. When the cold of the glacial epoch set in, ice formed to a considerable thickness over all the elevated parts of the land and descended in wide sheets in various directions upon the lower levels, carrying with it the softened or decomposed rock, which by the weight and motion of the ice became ground up to form the finer parts of the boulder clay or till. From the subsequent washing away of portions of this by the action of the sea and glacial lakes the Pleistocene clays and sands have been deposited. The glacial action continued till all the decayed crust had been carried away, and the bottoms of the glaciers were grinding on the sound rock beneath. What would we expect as the result of these processes? Naturally when the glacial ice disappeared, through a change of climate, there would be a hard, rounded, but uneven surface, as the rotting of these crystalline rocks had taken place to varying depths according to the previous contour of the land, or to the more or less decomposable nature of the different bands and in proportion to the unequal hardness of the undecomposed parts after they had been reached by the powerfully eroding glaciers. The angles of the dips, the curves and twists in the strike, the joints, and par-

Glacial origin of the lakes.

* See Geological Survey Report by Dr. Bell for 1871.

ticularly the dykes cutting these rocks, would all have their effect in modifying the form of the surface left at the close of the glacial epoch. The relative levels of the land, except on a continental scale, and its general contours, including the principal river valleys, probably existed before this epoch, and the latter guided the courses of the diminishing glaciers towards the close of the period, as may be seen by the direction of the striæ on the rocks along their bottoms. On the disappearance of the ice, the innumerable rock-basins which had been formed by the above process would be already full of water, and the rivers running in their present channels.

Origin of boulders.

It has been observed that in the decaying of crystalline rocks, as above described, small portions here and there remain unaffected, forming as it were kernels in the mass. These, with a little rounding by the action of the moving glaciers, would become the boulders or "hard-heads," so common in most parts of the country.

Decay of rocks still going on.

The high inclinations and almost vertical attitudes of the bedding or cleavage in most of the crystalline rocks has greatly favored the penetration of water and air, and their consequent destruction. In excavating the comparatively sound rock left under the glaciated surface at the present day, as in quarries and railway cuttings, we see how deeply the effects of these agencies are traceable, and they are even now laying the foundations of further decay.

The above short sketch of some of the most important points bearing on the superficial geology of Ontario is almost inseparably connected with the description of the geographical distribution and peculiarities of our Laurentian and Huronian country, and it will serve for reference in noticing the Pleistocene deposits in a subsequent part of this report.

Economic minerals.

The economic minerals of the Laurentian system and their modes of occurrence will be alluded to in the general description of the various kinds, under their respective headings further on.

HURONIAN SYSTEM.

Characteristics of the Huronian rocks.

This is the second principal division of the rocks of the earth in ascending order. In Canada it consists of a great thickness and variety of strata, for the most part crystalline, but in a less degree than the Laurentian, together with many unstratified igneous masses. Like the Laurentian it is azoic, or devoid of any trace of organic life, so that the distinction between the two systems is based entirely on lithological grounds. The difference in this respect is great, and is easily recognised by those who have paid any attention to geology. The prevailing dark green and grey colors of the Huronian offer a marked contrast to the lighter greys and reddish greys of the Laurentian. The latter are massive and coarsely crystalline, while the former are usually fine-grained and schistose or fissile, this cleavage structure constituting a striking difference from the solid Laurentian. There are some exceptions to this rule, such as the light colored quartzites and the granites and syenites of the Huronian to be noticed further on. The change in passing from one to the other is often sudden and complete, but sometimes beds of passage are met with.

Huronian areas.

As already stated, most of the Huronian areas occur within the general boundaries of the Azoic or Archæan rocks, and their relations to the Lauren-

tian have been pointed out. In addition to the numerous Huronian areas north of the great lakes and between Hudson bay and the North-west territories, there are certain rocks in the district stretching between the counties of Hastings and Lanark which may be regarded as belonging to this system. Some of the crystalline rocks of the Eastern Townships and of the provinces of New Brunswick, Nova Scotia, especially on the south-east side of Cape Breton, and Newfoundland also appear to belong to this division. The writer has found small Huronian areas on the eastern shores of James and Hudson bays, and in the eastern part of Labrador.

Disturbances.

In the midst of the larger Huronian areas limited portions are found where the strata are less disturbed than usual, or dip at moderate angles, just as similar conditions are occasionally found among the Laurentian rocks ; but a local circumstance of this kind does not affect the general character, nor afford a reason for separating these portions of either system from the rest. Examples of little disturbed sections of these rocks are met with near the Bruce Mines, lake Huron, on Montreal river and lake Temiscaming. Although the Huronian strata have generally been thrown into sharp folds, or stand at high angles, they are as a rule less bent about or contorted than the Laurentian.

Volume of the system.

In order to ascertain more correctly the nature of the Huronian deposits, the writer, in connection with the Geological Survey, commenced a detailed investigation of the Lake-of-the-Woods area in 1881 and 1883. These researches have since been continued by Dr. A. C. Lawson, and have shown that the different bands are not often persistent for any great distance, and that they vary much in thickness and change in lithological character when followed out on their courses. It therefore becomes difficult to estimate their thickness, even in a given area. From the sections measured by the late Mr. Alexander Murray, principally among the higher members of the series behind the Bruce Mines, that gentleman calculated that they have there a volume of about 18,000 feet. The total volume of the system must be very great—probably not far from 40,000 or 50,000 feet, or perhaps even more.

Conformity of the Laurentian and Huronian rocks.

In Canada, as far as our investigations have gone, the two systems appear to be everywhere conformable to one another; but in rocks of such ancient date and which have undergone such profound structural changes, owing to pressure, etc., affecting alike the stratified and unstratified portions, this appearance may not everywhere indicate a truly conformable sequence. The manner in which the Huronian rocks occupy spaces with elongated or even angular outlines in the midst of the Laurentian areas has been already referred to. Both sets of rocks having been thrown by lateral pressure into sharp folds, standing at high angles to the horizon, the Huronian often appear to dip under the older Laurentian, but this is merely the effect of overturning, and does not show that a part of the Laurentian is newer than the locally underlying Huronian. Notwithstanding the geographical relations of the two sets of rocks, their general difference in character and composition would indicate that some great change in terrestrial conditions had occurred when the formation of the one system ended and that of the other began. In the Laurentian an "acid" or silicious composition prevails, whereas the Huronian rocks as a whole are more basic, chemically speaking. The latter can be shown to be very

largely of volcanic origin, although this may not always be obvious at first sight.

Origin of the name.

The name Huronian (derived from lake Huron) was first given by the officers of the Geological Survey of Canada more than forty years ago, and it has been adopted by geologists in other countries as universally as the term Laurentian, and is made to include all the rocks lying between the Laurentian below it and the Cambrian or earliest fossiliferous rocks above. It thus forms an important and a convenient series, and its position in the geological scale is easy to recognise.

HURONIAN AREAS IN ONTARIO.

Huronian districts defined.

The greatest of all our Huronian areas forms a wide belt extending from the south-eastern extremity of lake Superior eastward along the north shore of lake Huron, from which it runs north-eastward, widening out till it occupies the whole country between lake Temiscaming and the head waters of the Montreal river, a breadth of one hundred miles. Beyond this it stretches north-westward across all the branches of the Moose river, northward beyond lake Abittibi, and north-eastward almost to the southern extremity of lake Mistassini, a distance of over 600 miles from the outlet of lake Superior. The Huronian area along the Ground-hog river, and Mattagami lake on its course, appears to be more or less completely separated from the great area above described. The next important Huronian district lies around Michipicoten at the north-east angle of lake Superior, running for sixty miles west and twenty miles south of that point, and extending inland to Dog lake, a distance of forty-five miles. Another large area stretches from the Pic river eastward or inland to Nottamasagami lake, and westward mingled with granites and green-stones, to Nipigon bay. Two extensive belts run eastward from lake Nipigon, one of which crosses Long lake. West of Thunder bay, and stretching to the international boundary line, there is a large area which gives off arms to the north-east and south-west; and several belts and compact and straggling areas occur between this and the Lake-of-the-Woods basin, one of which follows the course of the Seine river. The Lake-of-the-Woods area, which has been already alluded to, occupies the whole breadth of the northern division of that lake. An important belt starts between Rainy lake and Lake-of-the-Woods, and running north-eastward has a breadth of forty-five miles where it crosses the line of the Canadian Pacific railway. Minnietakie and Sturgeon lakes lie within this belt. Huronian rocks occur at both ends of lake St. Joseph and along three sections of the Albany river, between it and the commencement of the Palæozoic basin of James bay. The probability that some of the rocks of the Hastings and Lanark region may be classed with the Huronian has been already mentioned.

Local variations.

The rocks of these various areas, and of others beyond the limits of Ontario, in some cases show considerable variations in the proportions of the different kinds of which they are made up. This is only what we would naturally expect where their origin has been local, as shown by the rapidly changing volumes of their different components, although they may have been nearly or quite contemporaneous. In one area steatites, serpentines and dolomites are abundant; in another, conglomerates, breccias

and some amygdaloids; while in others we may find various crystalline schists, cherty and argillaceous slates, or it may be greywackés, quartz-diorites and quartzites, with slates and conglomerates.

LOWER AND UPPER DIVISIONS.

Although it will be difficult or impossible to draw any precise line of division applicable in all cases between the lower and upper parts of the Huronian rocks in Canada, yet for the sake of convenience they may be found separable, in a general way, into a lower and an upper series or formation. No horizon has yet been agreed upon at which to draw the line even locally, and the difficulty of an exact definition of a line is increased by the rapid changes of character in the lateral extension of any portion of the series. One of the United States geologists imagined that there was a general want of conformity between the lower and upper parts of what we had always called the Huronian rocks, and that a "basal conglomerate" was to be found at the contact of the two divisions; but there is no evidence whatever to bear out this supposition. Conglomerates are found indifferently throughout both the lower and upper portions. It may be a long time before we shall have worked out these rocks sufficiently to enable us to represent them separately on the map, but in the meantime it may perhaps be found convenient to speak of one set in a general way as distinguished from the other. Dr. Lawson proposed to call the Huronian rocks of the Lake-of-the-Woods region the "Keewatin" (more correctly spelled Kewaitin) series. This has the advantage of being a shorter name than the Huronian series of the Lake-of-the-Woods, but there are scores of other Huronian areas within the Dominion which are equally deserving of local names. Looking at the general geological map of the Dominion and the northern states, the Huronian as a whole is seen to occupy always the same place relatively to the rocks below and above it, and the general equivalency of all these areas cannot be disputed. Undefined lines of difference.

The lower division consists largely of a variety of crystalline schists, in which the prevailing color is dark green or grey. Among these may be enumerated micaceous, dioritic, chloritic, argillaceous, hornblendic, talcoid, felsitic, epidotic, siliceous, dolomitic and plumbagenous. There are also crystalline diorites or diabases of various shades of grey and greenish grey (mostly dark), argillaceous and dioritic slate-conglomerates, granites and syenites, impure, banded and schistose iron ores, dolomites and imperfect gneisses. Among the commoner of the rocks of this division are fine-grained mica-schists, and dark-green dioritic or hornblendic schists. Two kinds of conglomerates are also abundant, one having an argillaceous matrix, with rounded pebbles of syenite and granite of various kinds and of some of the other Huronian rocks, but very seldom of gneiss; the other with a dioritic matrix, and often with rounded pebbles also. But in perhaps the majority of cases what were formerly considered as pebbles are really concretions of a lenticular form, and differing but slightly from the matrix in color and composition. They are best seen on wetted surfaces of cross sections of the rock, where they appear as parallel elongated patches tapering to a point at each end. Both hematite and magnetic iron ores are common in these rocks, and they Peculiarities of the lower division.

have been largely worked in the Marquette and Republic districts in Michigan, and at Tower in northern Minnesota; but it is only lately that rich and workable deposits have been found among them in Ontario, although poorer ones have long been known in several localities. On the Antler river, about 100 miles west of Thunder bay, there is a very heavy deposit of rich and pure magnetite. Another is reported near the mouth of the Seine, and an extensive deposit of leaner ore to the east of Wabigoon lake. The late Professor R. D. Irving considered this feature of the Huronian so important that, for a short definition, he called it "a detrital iron-bearing series." But while the iron ores belong to the lower division, he attempted to restrict the name Huronian to some of the upper portions, which are not notably iron-bearing. The iron ores, whether workable or not, are generally accompanied by much red and dark jasper in thin layers. Gneiss is not common in the Huronian, and it differs from ordinary Laurentian gneiss in being imperfect, and also in being invariably slightly calcareous in all the numerous cases which have been tried by the writer. In some instances the felspar in it has been noticed to be triclinic, like those of the Upper Laurentian. Although rocks such as have been described as belonging to the lower division are largely developed in the Huronian areas to the west and north of lake Superior, they are by no means confined to these areas, but are met with in abundance in many parts of the great Huronian area north of lake Huron and elsewhere.

An iron-bearing series.

In the upper division probably the most abundant rock in Ontario is what may be called a graywacké, but which in the older reports was often styled a "slate-conglomerate;" but it also includes clay-slates, argillites, felsites, quartzites, ordinary conglomerates, jasper conglomerates, breccias, dolomites, serpentine, etc. In some localities the nearly vertical bands of quartzite, having withstood denudation better than the other rocks, remain as conspicuous hills or ridges, and this circumstance has caused their relative volume in the series to be over-rated by superficial observers. Within the province of Ontario these quartzites are most strongly developed near the height-of-land between lakes Abittibi and Temiscaming, and from the latter lake westward to the headwaters of the Montreal river. They are also common in the belt along the north shore of lake Huron, especially in its eastern part. The greywacké so abundant in the Huronian regions where the quartzites are chiefly found is composed of a matrix of grains of felspar and quartz, together with crystaline fragments of the two minerals (or a quartz-felspar rock) of all sizes from mere grains and chips up to those of pebbles, cobble-stones and boulders. These may be widely scattered in the matrix or crowded closely together, leaving only the interspaces to be filled by the finer debris. The fragments are sometimes quite angular; at others more or less rounded. This is the prevailing rock around lake Temagami, and is also abundant in the whole region drained by the Montreal river. It is also found all the way southward to lake Huron, but in this direction it is often associated with stratified quartzose-diorites and rocks intermediate between the two. The origin of the quartzites appears to be connected with rocks of the above kinds. The fact of their occurrence chiefly in the same regions and in association with them would suggest

Greywacké.

Huronian quartzites.

Origin of the quartzites.

this, but there is also direct proof leading to the same conclusion. The materials forming these greywackés and the stratified quartzose-diorites have been derived from volcanic sources, and coming into contact with water the quartz grains have been by some process separated from the other constituents. In the immediate vicinity of the parent rocks, beds composed more or less completely of these grains are to be found interstratifying other beds formed out of the other constituents. Sometimes these beds are quite thin and shade off vertically into one another, or alternate in great numbers within a limited section. Numerous examples of this arrangement may be seen in the township of Denison and the surrounding country. At greater distances the quartz grains are concentrated in larger volume forming quartzites, while the other ingredients make up the associated felsitic and argillaceous slates with layers of hornblende. The Huronian quartzites all contain grains of felspar in proportions varying from widely scattered particles up to about one-half their volume. Hand specimens of the latter variety bear a strong resemblance both in color and composition to rather fine-grained, reddish and greyish granites or quartz-syenites; but, besides the stratification on the larger scale, the internal structure of the rock is distinctly clastic or fragmental. Examples of these highly felsitic quartzites are to be met with throughout the country north of lake Huron. The coarser varieties are strikingly developed in the highest of the quartzite mountains north-westward of the northern outlet of lake Temagami. In this connection it is worth mentioning that the quartzite beds often found in the vicinity of the phosphate deposits of the Upper Laurentian formation in the county of Ottawa also contain grains of felspar more or less abundantly disseminated, showing that they were probably deposited in a mechanically mixed condition.

Felspar in the quartzites.

The formation of the quartzites being thus apparently connected with the greywackés and quartzose-diorites, they too would seem to partake of the general igneous history of the whole system, which, however, is more obvious in many of its other varieties of rocks. This igneous character is further proved by the large masses or areas of greenstones (diorites or diabases), granites, syenites and other eruptive rocks which are so largely mingled with both the lower and upper portions of the Huronian system in all parts of their distribution, forming indeed one of its characteristic features. The crystalline greenstones occur either as compact areas, wide elongated masses, dykes or thick interstratifying beds, in nearly all the Huronian areas. In many cases the dioritic schists may have been originally massive, but assumed the cleaved structure by pressure when incorporated among stratified masses. The commonest position of the granite and syenite areas is within but towards the borders of the Huronian tracts; but they sometimes occur in the Laurentian country, in their immediate vicinity or at a distance from them in the direction of the longer axis of the Huronian areas.

Igneous character of the system.

An attempt has been made quite lately among some American geologists to restrict the name Huronian to rocks like some of those north of lake Huron, although Sir William Logan and his colleagues in introducing the term originally described it as applying equally to the dark greyish and greenish schists, conglomerates, diorites, etc. The more extended investigations which

have since been made in Canada and other parts of the world have confirmed the propriety and convenience of including under this name all the rocks which had been originally described as Huronian.

THE METALLIFEROUS SERIES.

The metalliferous system of Ontario.

The Huronian, as above defined, is the great metalliferous system of Ontario, and indeed of all Canada, and hence its great importance in the economic geology of the country. The whole series is more or less metalliferous, but the various ores are not uniformly distributed, some occurring in one region or in some special stratum, while others may prevail in another section of country or in a different horizon in the series. Besides metallic ores, the Huronian also contains various rocks and non-metallic minerals of value.

IRON.

Occurrence of iron ores.

Iron appears to occur most frequently in the lower or schistose portions of the system. At one place examined by the writer on the Antler river, about 100 miles west-north-west of Port Arthur, there is a large deposit of magnetite of fine quality. In the widest part there are three beds, each about fifty feet in width, separated from each other by only narrow bands of rock, running with the general course of the belt to which they belong. The deposit shows workable quantities of ore at intervals for about three miles, and is traceable for about five miles. No jasper was observed at this locality. Another rich deposit is reported to have been discovered on the Seine river, near its mouth, and one of lower grade ore at a straggling lake at no great distance south-eastward of Wabigoon lake. The iron ores associated with jasper which have been found on the southern part of Hunter's island and near Gunflint lake appear to belong to a continuation of the belt in which the rich deposit of Tower, in the adjoining state of Minnesota, occurs. A belt of fine-grained magnetite in thin layers, alternating with equally thin layers of red jasper, was found and described by the writer in 1869 in the hills on the east side of the Kaministiquia river, just below the place where it is now crossed by the Canadian Pacific railway.* During the same season Mr. Peter McKellar, while assisting the writer to make a topographical and geological survey of lake Nipigon, found a deposit of hematite on its eastern side, near Sturgeon river. A common form of iron ore in the Huronian rocks consists of thin layers of magnetite, or occasionally of hematite, alternating with similar layers of compact or fine-grained grey quartz in the same manner as the jasper just described. These layers vary from one-sixteenth of an inch to an inch and more in thickness, but are usually from about one-eighth to one-half an inch. These ores sometimes occur in large quantities, and although too poor to work (unless some economic process should be discovered for separating the magnetite from the rock), they are nevertheless worth careful examination in the hope of finding the ore in a more concentrated form in some parts. Ores of this character or of a similar class, as far as their economic value is concerned, have been found at the following localities:

Localities.

South-west arm of Red lake, northward of Lake-of-the-woods.
Township of Moss.
Near the height-of-land, south-west of the head of lake St. Joseph, loose.

* See Geological Survey Report for 1869.

Near Little Long lake, west of the north end of Long lake.
Albany river, near the junction of Etow-i-mami river.
The largest of the Slate islands, lake Superior.
Gros Cap, near Michipicoten.
Oka or Pickerel river, west of Michipicoten, reported.
Jackfish bay, reported.
Near Montreal river, lake Superior, reported.
North of Batchawana bay on the Peter Bell location, and in larger quantities at the head of Pancake river.
In one of the south-western bays of Temagami lake.
At a small lake north of the eastern arm of Temagami lake.
Quinze rapids and Opazatika lake, above lake Temiscaming.
At Abittibi lake.

The lean iron ores, composed of thin layers of magnetite interstratifying others of a siliceous rock, in the township of Dalhousie, Lanark county, and adjacent regions are also of this class, and they form another link connecting the rocks of this district with the recognised Huronian. The iron mines of eastern Ontario which were visited by the Commissioners are described in another part of this report.

COPPER AND NICKEL.

Copper is very generally diffused throughout the Huronian rocks, but the principal deposits heretofore worked, those of the Bruce Mines and the Sudbury region, are associated with rocks of the supposed upper division. At the former locality the workings extended for nearly two miles across the Bruce, Wellington and Huron Copper Bay locations. They were carried on chiefly upon two east and west quartz lodes cutting greenstone, the Main lode varying from about three to fifteen feet in thickness, while the other, called the New or Fire lode, is a branch of this. The workings extended to a depth of about seventy fathoms in many parts. The ore was mainly copper pyrites, but a good deal of the purple sulphide was found near the surface. Operations were carried on from 1846 to 1876, and the gross value of the output was ascertained by the writer (through the courtesy of Captain Plummer and others) to be about $3,300,000.

Copper of the Bruce Mines and Sudbury regions.

Copper in the form of the yellow sulphide, associated with pyrrhotite or grey magnetic iron pyrites, is met with in considerable quantities in a number of localities around Sudbury Junction, on the Canadian Pacific railway, and thence along the Sault Ste. Marie branch to the Spanish river. As far as they have been tested these ores also contain sulphide of nickel, often in quantities which should pay to extract. The ore in this region is associated with an obscurely stratified greenstone, and its mode of occurrence is apparently that of large masses and "impregnations," having roughly lenticular forms and following fahlbands which are rudely comformable with the general stratification of the country rocks. These masses enclose many "boulders" or fragments of all sizes of greenstones and greywacké, which are often finely impregnated with copper and iron pyrites. Most of the ore is low grade, but in the midst of this considerable bunches of pure copper pyrites occur, while on the other hand some portions consist of almost pure pyrrhotite. The country-rock in this neighborhood everywhere dips at high angles, or is nearly perpendicular, and the ore-masses follow these inclinations. An

Its mode of occurrence in the Sudbury district.

important feature of these masses is their great size, so that although the average percentage of copper and nickel is low (yet sufficient for profitable working), the quantity is so large as to give promise of great productiveness.

First discoveries at Sudbury.

Copper ore was first discovered in this district in 1882, during the construction of the Canadian Pacific railway, at a point on the main line (since called the Murray mine) about three miles north-west of Sudbury Junction. This was soon followed by the finding of the Stobie mine, three and a half miles north, and the Copper-cliff mine an equal distance to the south-west of the junction. At the Stobie mine, which is worked as an open quarry, an ore-mass of the nature above described appears to have a thickness of upwards of a hundred feet and it has been traced south-westward on the strike as a series of lenticular copper-bearing masses, separated by pinched intervals, for a distance of a mile and a-half. The Copper-cliff mine shows a vein-like deposit of mixed pyrites about ten feet wide, containing a higher percentage of copper than the Stobie ore, and also a number of the lens-shaped ore-masses. It has been worked to a depth of over 400 feet on the slope and has yielded a large quantity of good ore. The Evans mine is about a mile south-south-west of the Copper-cliff. Here the ore-bearing mass, as proved by the diamond drill, appears to be nearly 100 feet thick, but it consists largely of pyrrhotite, rich in nickel. In the township of Denison a vein of copper pyrites, with a high percentage of nickel in some parts, has been opened by the Vermilion Mining company on lot 6 of the 4th concession; and on the line between the 5th or Krean lot and the 4th or McConnell lot, both in the 5th concession, and about a mile to the north-north-east of the Vermilion mine, the surface appearances indicate a promising deposit of copper ore similar to those near Sudbury, but no mining has yet been done at this locality.

Stobie, Copper-cliff and Evans mines.

Denison township veins.

The discovery of nickeliferous copper pyrites around Sudbury recalled the fact that similar ore had been found nearly forty years before at the Wallace mine, on the shore of lake Huron near the mouth of the Whitefish river. The deposits at the two localities appear to lie in the same geological horizon, and, in following the general strike of the rocks north-eastward from the Wallace mine, ores of copper have been found near the west end of lake Panache, in the townships of Drury, Denison, Graham, Waters, Snider, McKim and Blezard, on the west side of the Wahnapitæ lake, near the north end of Lady Evelyn lake, on Montreal river, on Blanche river, at a place near the height-of-land not far east of the canoe-route from lake Temiscaming to Abittibi lake, and finally near the south end of lake Mistassini. This will probably prove to be a copper-producing region of vast importance in the future, of which the present discoveries are only the first indications. Copper has been found in many other places in the Huronian rocks of Ontario, and these will be referred to further on in the list of localities of this metal, but the foregoing short descriptions will serve to give an idea of its two principal modes of occurrence in these rocks.

A copper belt extending from lake Huron to lake Mistassini.

GOLD.

Gold promises to become an important product of our Huronian rocks, notwithstanding the fact that only partial success has attended the efforts heretofore made to mine and extract it. If we include the gold-bearing rocks of the Hastings region amongst the Huronian, it becomes doubtful if the precious metal has been found, except in the merest traces, in any other formation. Not long ago the occurrence of gold was unknown in Ontario beyond the traces which had been found in assaying the silver and copper ores of Prince's location, of Michipicoten island, and the vein-stuff of the Bruce mines; but now it has been discovered in so many and such widely separated localities in the province, and in some cases under such promising conditions, that it is highly probable that successful gold mines will be established after more thorough tests have been made. The importance of recent gold discoveries.

The first discovery of gold in notable quantity was made in 1871 by Mr. Peter McKellar (following up a clue obtained from an Indian) near Jackfish lake, at what is now called the Huronian mine, situated on location H1 in the township of Moss. It here occurs in a true and persistent vein from 6 to 8 feet wide, of which from 2 to 5 feet are quartz, the rest being incorporated schist. The country-rock consists of interbedded talcoid, chloritic, dioritic and a little dolomitic schist, siliceous magnetite and massive diorite, all dipping north-west at angles of 65° to 80°. The vein runs north-eastward, cutting the strata at a small angle and underlying to the north-west side at an inclination of 15° from the perpendicular. Intrusive syenite appears about a mile to the north-east of the mine, and this may have had something to do with the enrichment of the vein. The gold occurs free and as sylvanite (or telluride of gold) associated with galena, iron and copper pyrites and blende, which, with the white quartz, constitute a beautiful looking ore. A 10-stamp mill was erected in 1883 at great expense, on account of the difficulties of transportation, and in 1884 some mining and milling were done. The gold secured is understood to have been equal to $21 to the ton, which was, however, far short of the whole amount contained in the ore. Work was resumed for three or four months in 1885, but, from the want of proper means of transportation to the mine, operations are for the present suspended. Openings have been made and similar ore obtained from a continuation of the same vein, called the Highland mine. The Huronian gold mine.

Gold was discovered on Lake-of-the-Woods in 1878, or earlier. In the writer's Geological Survey report for 1881, page 15c, it is stated that "in 1879 I was presented by Mr. J. Dewé with a specimen from Hay island, of white quartz containing needle-like crystals of hornblende with a little calc-spar, which showed distinct specks of gold. It was assayed by Mr. Hoffmann, chemist to the survey, and found to contain 37.318 ounces of gold and 1.431 ounces of silver to the ton of 2,000 pounds." During the succeeding four or five years some mining was done at a few places around the northern part of this lake, and in some instances with the prospect of ultimate success, but owing to the impossibility of obtaining titles, on account of the dispute between the Dominion and the Ontario governments as to the ownership of the Gold locations on Lake-of-the-Woods.

territory, it was impossible to obtain sufficient capital and no thorough test has yet been made to determine the real productiveness or otherwise of any of the mines. Trials have been made at several promising places, such as Sultana island, the Winnipeg Consolidated and the Pine Portage properties, and now that the matter of title is set at rest there is a probability that work will be prosecuted on a sufficient scale to determine the question whether gold is to be found in this region in paying quantities or not. It occurs both free and in combination with sulphides in veins of quartz more or less split up and interrupted, cutting green schists and not far from masses of syenite. These deposits would appear to lie towards the bottom of the series as developed at the Lake-of-the-Woods. Specimens of free gold in quartz have been shown to the writer as having been obtained not far from Taché, on the Canadian Pacific railway.

Partridge lake gold veins.

At Partridge lake, a short distance west of Lac-des-Mille-Lacs, gold was discovered in 1872 by Mr. Archibald McKellar in a large vein of quartz cutting Huronian schist on an islet, and also in large veins of the same material in the strike of this one on either side of the lake. Assays of the quartz from both the islet and the mainland, which were made by Dr. Girdwood, showed from 1 to 1½ ounces of gold to the ton. A number of small nuggets were obtained by breaking up the quartz on the islet by both Mr. McKellar and Mr. W. W. Russell, and shown at the Philadelphia exhibition in 1876. This locality was visited by the writer last summer on behalf of the Commission, and samples of the quartz and photographs of the outcrop of the vein were obtained.

Victoria Cape location.

In 1875 Mr. Donald McKellar found small nuggets of gold in a vein of quartz cutting reddish granite at Victoria cape on the western side of Jackfish bay, on the north shore of lake Superior. Another vein of quartz 1½ to 3½ feet thick, holding iron pyrites, galena and blende and cutting the granite in close proximity to slaty diorite at this locality, yielded on assay $27 worth of gold per ton.

Various other locations.

The Commissioners were credibly informed that gold associated with iron pyrites had been discovered in quartz veins between Goulais and Batchawana bays, at the east end of lake Superior, and also on a small island near the shore of lake Huron, north of Lacloche island. Traces of the metal have been found by assay in the laboratory of the Geological Survey in quartz from veins near the north end of Temagami lake, and from Cross lake to the south of this sheet of water.

Vermilion Mine location.

At the Vermilion gold mine on lot 6 in the 4th concession of the township of Denison, in the Sudbury district, coarse free gold was found at and near the surface in a vein of light grey granular quartz about two feet thick, running north-eastward, and cutting grey or ash-colored greywacké, bearing a close resemblance to the "whin-rock" of the Nova Scotia gold districts. The gold was so thickly disseminated in one part of the vein as to hold together fragments of the quartz after they had been fractured by the hammer. On the same lot a ridge of greyish diorite rises a short distance to the south-east of this vein, and a few specks of gold were seen by the writer in the

midst of iron-stained spots on the weathered surface of this rock. Visible gold is said to have been found also in a quartz vein at the east end of the Indian reserve on the south side of the mouth of the Spanish river.

Gold on lake Wahnapitæ.

Gold was discovered in the summer of 1888 on a point on the southern shore of lake Wahnapitæ, between the two deep bays on that side of the lake. It occurs, as far as could be observed by the writer, who visited the place in September, in several narrow veins of white quartz cutting a highly felspathic reddish quartzite, resembling fine grained granite, but distinctly clastic or fragmental in origin. No single vein or group of small veins could be traced far, but where any of them gave out others were observed to commence not far off. They are "bound" veins, or adhere closely to the wall-rock, or are, as it were, fused into it. One of these little veins shows a good deal of mispickel and some iron pyrites in crystals along one side of it. An assay of a sample from this vein, made by Mr. Hoffmann, chemist of the Geological Survey, yielded at the rate of 5.425 ounces of gold and 0.233 of an ounce of silver to the ton of 2,000 pounds, while the quartz from another of these veins showed neither gold nor silver. The visible gold of these veins occurs as specks and small nuggets in the quartz. It is also said to have been detected in the wall-rock apart from the veins, and, if so, this circumstance may prove to be of great importance, for if it should be found to pay at all to treat the whole mass, great profits might be realised by doing so on a large scale. The rock at this locality resembles that of the famous Treadwell mine on Douglas island in Alaska, both in composition and in the manner of the occurrence of the small adherent quartz veins, but the latter rock is almost white and is dotted with small particles of iron pyrites. A microscopic examination of the ore of the Treadwell mine, which has just been made by Mr. F. D. Adams of the Geological Survey, shows it to consist of a granite-like rock in which the clastic character may be due to a process of crushing after its solidification. Although the rock of the Treadwell mine yields only about $5 worth of gold to the ton, immense profits are made by stamping and treating it in large quantities, and it is in this direction rather than in the great richness of small quantities that we must look for profitable gold mines in our Huronian rocks. It may be here remarked that gold is said to have been profitably extracted from two mines in Huronian rocks on the south side of lake Superior.

Comparison with Treadwell mine, Alaska.

Gold in the Hastings region.

In the early part of August, 1866, gold was discovered by a man named Powell and a Dutch miner on the eastern part of lot 18, range 5, in the township of Madoc, belonging to Mr. J. Richardson, who, however, did not recognise it as the precious metal till informed of the fact by the late Mr. H. G. Vennor of the Geological Survey, who was then working in the neighborhood. Mr. Vennor in his report for that year, addressed to Sir William Logan, described the gold as occurring in "a series of crevices or openings in a gold-bearing bed, formed of chloritic and epidotic gneiss (or schist) holding patches of dolomite and calcspar, the openings being nothing more than such as are so often met with in the dolomites and calc-schists of this region." The gold was found along with particles of black carbonaceous matter in a

Richardson mine.

brown ferruginous earth filling the longitudinal crevices, paralled to the bedding, one of which had been struck at a depth of 4 and another at 15 feet from the surface at the time of Mr. Vennor's visit. Numerous small nuggets were also found enclosed in the adjacent dolomite and calcspar. The strata here dip nearly due north at an angle of 45°, and the gold-bearing bed is "overlaid by a siliceous ferruginous dolomite and underlaid by a band resembling an impure steatite." Its geological position is not far above the iron-bearing belt of that region. The Richardson mine has been worked at different times since the above date, and a good deal of gold extracted from it.

Other localities of gold.

This discovery was followed by many others of the precious metal which have been made at different times in the townships of Marmora, Madoc, Elzevir, Kaladar, Lake and Tudor, and there is now a probability of gold-mining becoming an established industry in this region. One of the most notable of the attempts at gold mining in the district is that at the Gatling (since called the Canada Consolidated) mine in the township of Marmora.

Gatling mine.

The gold here occurs in veins of quartz containing much mispickel and cutting a crushed syenite or a mixture of schist and syenite, close to a large area of the latter rock. Assays of twelve different samples of the ores of this mine gave an average of 1.9107 ounces or $39.47 to the ton of 2,000 pounds. In spite of this richness, the difficulty of separating the gold from the sulphide of arsenic is so great that only partial success has attended the working of the mine, after the expenditure of a large sum of money in buildings, machinery, working the mine and experimenting.

Gladstone and Feigle mine.

A considerable quantity of gold has been extracted from the Gladstone and Feigle mine, situated on the continuation of the same set of veins as the Canada Consolidated, at a distance of two or three miles to the northward of it.

Dean and Williams mine.

Another mine called the Dean and Williams on lot 8, range 9 of Marmora, about a mile and a-half southward of the Canada Consolidated, was worked for a time with some success.

Guinard mine, Kaladar.

At present it is reported that from six to eight dollars worth of gold per ton are being extracted at the Guinard mine, in Kaladar, from a set of small quartz veins cutting a rock which is described as a conglomerate with quartz pebbles in a matrix of micaceous schist.

Silver in Huronian rocks.

Some veins have been discovered in the Huronian rocks containing silver in promising quantities—sufficiently so at any rate to warrant the search for more. The vein at the Huronian mine is a case in point, but the silver there was pratically overlooked in the efforts to extract the gold.

3A mine.

The 3A mine on the north shore of Thunder bay was opened on a vein of quartz and bitter-spar from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet wide and running about east-north-east, or parallel to the strata, which, according to Mr. Peter McKellar, here "consist of thick beds of diorite and fine grained greenish-grey slates, some of which are chloritic, talcose, calcareous and ferruginous, with some serpentine alongside of and in the vein." Dark greyish red syenite is met with a short distance to the south. The silver occurs both native and in combination with sulphur and nickel, and it is associated with iron and copper pyrites, galena and blende. There is also a small proportion of gold along with the silver.

This vein was discovered in 1870. Active operations were begun early in the spring of 1873, and after having been worked to a depth of about 150 feet and yielding several thousand dollars' worth of silver in the form of bunches of very rich ore, work was suspended in the spring of 1874. Two veins were discovered in 1872 within a mile of Heron bay and close to the Pic river, which, judging from the ore brought to the shore of lake Superior and examined by the writer, bear a strong resemblance to that of the Huronian mine. The width of each is given by Mr. Peter McKellar as ranging from a foot to four feet at the surface. They lie in a large Huronian area and are described as cutting talcoid and chloritic schists, while a boss of intrusive granite rises beside the Pic river at no great distance to the eastward, giving an additional point of resemblance to the surroundings of the Huronian mine. One of the veins runs east-north-east with the stratification, while the other strikes nearly north and south. At a depth of 40 feet the latter had opened out to 5 or 6 feet in width. The gangue in both veins consists of bitter-spar and quartz, and contains galena, blende, iron and copper pyrites, together with gold and silver, ranging from traces up to about $70 worth of each to the ton, according to assays made by Mr. McDermid, who was assayer at the Silver Islet mine at the time the above work was done. Heron bay.

GALENA.

The Victoria argentiferous galena vein, situated near Garden river and about eight miles north from its mouth, occurs in Huronian rocks. It runs about north-north-west, parallel to the western side of an extensive mass of very fine-grained reddish-grey granite or quartz-felspar rock, from which it is separated by a few feet of glossy green schist and tough green trappean rock, some of the latter approaching the character of an amygdaloid. Work was commenced at the Victoria mine in 1875, and at the time of the writer's visit in 1876 two shafts had been sunk, each to a depth of 15 feet, in the midst of a belt 36 feet thick, of glossy-surfaced green schist, cleaving in all directions and containing galena in strings, grains and small bunches. One of the shafts followed a vein of solid galena, mixed with considerable dark blende and a little copper and iron pyrites, from 8 to 19 inches thick, and the other a similar vein 10 inches thick, but containing a mixture of quartz. This lead-bearing belt of schist is succeeded on the west by siliceous felsites and dark green and rather coarsely crystalline hornblende-rock, which is again followed by fine-grained light reddish or pinkish-grey granite. This belt of veins was afterwards worked to a considerable depth, and a large quantity of galena taken out and exported. The proportion of silver varied from a few ounces up to 168 to the ton of 2,000 pounds, most of the ore being tolerably rich. The Cascade mine, a short distance to the northward of the Victoria, is said to be on the same belt and to resemble the latter in most respects. Argentiferous galena has also been found in Huronian rocks in the Sudbury district, a short distance south of Straight lake, and in the north-western part of the township of Creighton, and again near the north end of Lady Evelyn lake, which lies between Temagami lake and the Montreal river. Victoria mine, Garden river. Cascade mine. Sudbury district.

The Victoria and Cascade mines are the only places at which any lead mining has been done in Huronian rocks, unless the galena veins of Tudor, Limerick, etc. in the Hastings-Lanark region should prove to be situated in rocks of this age.

Other galena veins.

ZINC.

Zinc at Zenith mine.

Zinc, in the form of blende (or sulphide of the metal), was discovered in 1881 in large quantities at a place which has been named the Zenith mine, situated on the White Sand river, about ten miles northward of the shore of lake Superior opposite Wilson's island, eastward of Nipigon bay. The ore is black and crystalline, and is described as occurring principally in two large veins or lenticular masses in a hornblende rock or diorite of Huronian age. The ore could be mined with great facility, and some 400 or 500 tons are said to have been already excavated, but it cannot be brought to market for want of a road. A specimen analysed by Mr. Hoffmann, chemist to the Geological Survey, gave 54¼ per cent. of metallic zinc. This is the only locality at which zinc ore has been discovered in large masses in the Huronian system in Canada, and it is therefore interesting as an indication that the metal may be found in paying quantities in these rocks in other places. Blende in large crystals occurs in a vein of coarse calcspar about eight feet wide at Blende lake, about 1½ miles north-north-west of the head of Thunder bay. The south wall of the vein, which runs east and west, consists of dioritic schist of Huronian age, while the north wall is formed by ferruginous and siliceous clay-slates belonging to the Animikie series. The occurrence of blende with the galena of the Victoria mine has been already referred to.

Blende lake, Thunder bay.

ANTIMONY.

Antimony near Echo lake and Garden river.

In the report of the writer for 1876, page 211 (Geological Survey Report) reference is made to a reputed discovery of sulphide of antimony in a vein of white quartz cutting felspathic grey quartzite (Huronian) about one mile west of Fairy lake, near Echo lake. Mr. Joseph Cozens, of Sault Ste. Marie, states that he has discovered a vein eight inches wide, rich in this ore, among the Huronian rocks on Garden river.

OTHER METALS AND MINERALS.

Other metals found in Huronian rocks.

The above descriptions will serve to show that the Huronian rocks contain ores of the various metals referred to in economic quantities. The occurrence in them of nickel, arsenic and tellurium has been incidentally mentioned. In addition to the metals already alluded to, platinum, tin, molybdenum, bismuth and cobalt have also been found among these rocks, but our space will not admit of a fuller description of them than that contained in the list further on. The number of discoveries of valuable ores already made must be regarded as very encouraging, considering how little knowledge we possess as to the geological relations and modes of occurrence of the metals in the Huronian system and the comparatively small amount of *bona fide* and intelligent exploration which has yet been done, and leads to the belief that many districts situated on this extensive system will prove rich in metallic ores.

Among the rocks and non-metallic minerals of economic value to be met with in the Huronian system, the following may be mentioned: fine granites and syenites for buildings, monuments and ornamental purposes; sandstones, quartzites and greywackés for construction; flagstones, roofing slates, serpentine and dolomitic marbles, ornamental argillites, jasper conglomerate; white quartzite for glass-making; asbestos (chrysotile), graphite, actinolite and barytes.

Useful rocks and non-metallic minerals.

THE CAMBRIAN SYSTEM.

This system was so called by the late Professor Sedgwick from Cambria, the ancient name for Wales. It is the oldest one in which the remains of organic life have been found, being the first above the Archæan rocks. Besides ordinary sedimentary deposits, such as limestones, sandstones, shales, etc., it comprises, in some regions, a large proportion of igneous and other non-fossiliferous rocks, the whole thickness of the system amounting to many thousands of feet. The fossils, when present, consist only of marine invertebrate animals, among which trilobites are conspicuous, both as to size and the number of species. Remains of marine plants are also found in these rocks. The system is well developed in Bohemia, Wales, Newfoundland, New Brunswick and Ontario, as well as in some parts of the United States.

Rocks composing the Cambrian system.

ANIMIKIE FORMATION.

The name Animikie is derived from the Outchipwai word for thunder, and is appropriate inasmuch as these rocks are most largely developed around Thunder bay. Although no fossils have yet been found in the Animikie formation, it consists largely of undisturbed and unaltered sedimentary rocks and is classified with the Cambrian. It is the first formation above the Archæan, and rests almost horizontally upon the denuded edges of the upturned Huronian and Laurentian strata of the region. Its thickness has not been clearly ascertained, but it probably amounts to 2,500 or 3,000 feet or more.*

Derivation of Animikie.

The Animikie strata in ascending order consist of: (1) Greenish arenaceous conglomerate with pebbles of quartz, jasper and slate—seen on the north shore of Thunder bay. (2) Thinly bedded cherts, mostly of dark colors with argillaceous and dolomitic beds—seen at the head of Thunder bay and along the northern boundary of the formation in the township of McIntyre. (3) Black and grey argillites and flaggy black shales with sandstones and ferruginous dolomitic bands and arenaceous beds, often rich in magnetic iron,

Nature of the rocks.

* The Silver Islet mine was sunk through 1,230 feet of these rocks lying almost horizontally below the level of lake Superior, and on the main shore opposite to the mine they rise about 800 or 900 feet above the lake, in addition to a trap overflow of 400 or 500 feet, which however may belong to the next higher formation; so that we have here an actual section of some 2,000 feet. Mr. E. D. Ingall says (Report of Geological Survey for 1887, page 25 H): "If we assume the average dip to be in a south-south-east direction and measure the width of the outcrop of the formation from Grand Portage island where it passes under the overlying Keweenawan rocks north-north-west to near Woodside's vein in the Silver mountain area where the Archæan appears from below them, which we find to be some 25 miles, we get a thickness for these rocks of over 12,000 feet." But on the same page he says, "As has been already mentioned, the formation lies nearly flat, and it is very difficult to decide whether it really has any general dip or not."

together with layers and intrusive masses of trap (diabase). This is by far the thickest division, constituting in fact the bulk of the formation. Lenticular and spheroidal concretions of various sizes, called also bombs, boulders and kettles, are common throughout the black shales of this division.

Geographical distribution of the formation.

Geographically the Animikie formation in Ontario occupies a triangular area, of which the base, 60 miles in length, extends from the mouth of Pigeon river westward along the international boundary to Gunflint lake, while one of the other sides is formed by the shore of lake Superior from Pigeon river to Goose point on Thunder bay, 40 miles in length, and the third side by a line joining this point and Gunflint lake, about 80 miles in length. The lower portions of the formation extend over the comparatively level ground within this area to the northward of the Kaministiquia and Whitefish rivers, while the higher measures, lying almost horizontally, occupy the mountainous country stretching from these streams southeastward to the shore of lake Superior. The summits of most of the hills in this district are capped with thick and nearly horizontal beds of trap, giving them a flat or table-topped appearance. If all these isolated areas of trap were represented on a geological map of the district it would have a "spotty" appearance, the total extent of the trap being much less than that of the underlying shales which occupy the hill-slopes and the bottoms of the valleys between them. A good idea of the geology of this district may be formed if we suppose the crowning overflow to have been once continuous, but that afterwards extensive erosion of both the trap and the underlying shales took place, leaving only the detatched portions or islands we now see. There is evidence of some faulting in various parts of the district which may account for the difference in level of some of these trappean cappings. The crowning overflows are, however, not the only beds of trap which exist in the formation, as was pointed out many years ago by Sir William Logan and the writer, and more recently by Mr. Ingall. Examples of this may be seen along the Pacific railway track east of Port Arthur, on the islands and points of the north side of Thunder bay, at the mouth of Current river, and between the Duncan mine and Port Arthur, as well as within the limits of that town itself. One of these beds of trap forms a conspicuous escarpment with a long slope to the southward on mining-lot L in the township of McIntyre, which may be seen from Thunder bay. The nearly horizontal layers or masses of trap in these rocks may not have been surface-flows in all cases. Some of them appear as if they might have been injected under pressure between the bedding of the shales and other rocks, and in such cases they do not seem to extend very far.

Table-topped hills.

Several beds of trap.

Other localities of Animikie rocks.

The Animikie rocks are found near the water's edge along the south-east side of Thunder bay, as far as Thunder cape and around its southern side, including the islands to a point east of Silver islet; also in places along the main shore and on some of the islands about Rossport, east of Nipigon bay. They likewise form Pie island and the chain of islands extending thence near the coast to Pigeon river. The Animikie rocks do not appear to extend far into Minnesota, being replaced by higher strata south of the boundary.

They are said, however, to recur on the south side of lake Superior in the northern parts of Wisconsin and Michigan, but in a disturbed condition and otherwise differing from the Canadian type.

THE SILVER-BEARING ROCKS.

The Animikie rocks are of great importance as being the silver-bearing formation of Ontario. Nearly all the veins cutting these rocks bear a strong resemblance to one another in the nature of the gangue which fills them, so much so that these veinstones may be said to form one of the characteristics of the formation. They are generally open or drusy, brecciated and very crystalline, consisting in most cases of white quartz and calcspar mixed with fragments of the wall-rock and a smaller proportion of green and purple fluorspar; but in some instances, as at McKellar's island and in most of the veins on the islands and mainland between Thunder bay and Pigeon point, white barytes forms one of the principal constituents. A part of the crystalline quartz is almost invariably amethystine, and this color has also been imparted to the quartz crystals of the veins in the older rocks of the neighborhood, once covered by the Animikie, which is not the case in similar veins at a distance, showing that the character of veins may be influenced by the rocks above. The veins of the Animikie formation are apt to be gathered into solid bodies where they traverse the harder beds and the trap layers, and to become scattered into a number of strings or reduced to mere faults, or to be pinched out altogether in passing through the softer strata, such as the black shales.

The silver-bearing formation of Ontario.

Variations in veins.

The silver occurs native in grains, threads and small branching forms, and as argentite in leaves and small masses, but occasionally in large crystalline lumps, as at the Rabbit Mountain mine. At Silver islet heavier native silver and two new silver compounds, Huntilite and Animikite, were found. The associated sulphides in nearly all the veins are blende, galena, copper and iron pyrites, and their relative proneness to carry silver has been found by many assays to be in the order in which they are here mentioned. In the same way they have also been found to be richer in silver in proportion as they are more closely associated with the visible silver itself, and to contain very little when remote from the rich ore of the vein. No law governing the conditions or mode of occurrence of the silver in the veins has yet been discovered, and its apparently sporadic distribution in them makes it necessary to prospect extensively underground in each case before a vein can be pronounced valuable or otherwise.

Forms of silver.

Uncertain distribution of silver.

The veins in the Animikie rocks run principally in two general directions, one about north-east or east-north-east to east, and the other about north-north-west. The veins of the Beck or Silver Harbor, the Thunder Bay and Duncan mines and the majority of those in the townships of McIntyre and Neebing and in the Rabbit mountain and Silver mountain districts belong to the former, while those of the Beaver and Silver islet mines and the numerous veins traversing the islands and the mining locations on the mainland between Thunder bay and Pigeon point belong to the north-north-west group.

Courses of veins.

The first discovery of silver of any consequence on lake Superior was made by Mr. Peter McKellar in the autumn of 1866, at what afterwards

became the Thunder Bay mine. The metal was here found in the form of grains and threads of native silver thickly disseminated in a vein of light grey granular quartz from 1 to 3 feet wide, running north 34° east and cutting dark shale and argillite, interstratified with impure ferruginous dolomite and overlaid by a bed of trap. This vein was worked in the summers of 1869 and 1870, in each of which years it was visited by the writer. Notwithstanding its great richness at the surface it failed to produce any large amount of silver, and work was discontinued after reaching a depth of only 70 feet in each of the two shafts which were sunk. Operations were resumed in 1875 on a parallel reticulated vein in argillite, having a breadth of 6 to 12 feet in all, which was struck by cross-cutting underground at a distance of about 20 feet south of the silver-bearing vein. This opening was inspected by the writer in 1875, but no silver could be detected. Further exploration along the course of these veins may give better results.

Thunder Bay mine.

The vein of the Shuniah, afterwards called the Duncan mine, was discovered to be silver-bearing by Mr. John McKellar and Mr. George A. McVicar in May, 1867, or about a year after the discovery of the Thunder Bay mine. The vein is very large, being 20 to 30 feet in width, runs east and west and consists of quartz and calcspar. The Duncan mining company showed great courage and perseverance in working this property, and only abandoned it after spending about half a million dollars and sinking to a depth of 800 feet, with galleries at different levels. Only about $20,000 worth of silver in all was obtained. The Animikie rocks were here found to extend to about half the above depth, and below this were Huronian schists with syenite on or near the north wall of the vein. A considerable area of trap occurs on the surface to the south of the vein.

Shuniah or Duncan mine.

The vein at the Silver Harbor or Beck mine was discovered by Ambrose Cyrette in 1870, and was worked in 1871 and 1872. It cuts the shales and chert beds of the lower part of the formation, which are here overlaid by a bed of trap. It runs east-north-east, and is about 5 feet in thickness. The gangue is of a brecciated character, and consists of white quartz and calcspar with a little fluorspar and amethyst. Some native silver was obtained in association with galena, blende and iron pyrites, but the quantity does not appear to have been remunerative.

Silver Harbor or Beck mine.

The Montreal mining company having employed Mr. Thomas Macfarlane, a well known geologist, to survey and prospect their locations on lake Superior in 1868, his assistant, Mr. Gerald Brown, while triangulating the shore of Wood's location, sent one of his men, John Morgan, to plant a picket on a rock in the water, afterwards called Silver islet. While doing this Morgan found the silver-bearing part of this now famous vein,* and brought a specimen from it to Mr. Brown. Mr. Macfarlane took out some $1,500 worth of silver with one or two blasts at the surface and sent it to Montreal. The vein was further prospected to a small extent by the Montreal company the next year, but in 1870 this property, along with all the other locations of the company,

Discovery of Silver Islet mine.

* In the Geology of Canada, page 707, Sir William Logan describes the Silver islet vein where it crosses Burnt island as "a very prominent lode holding galena and green carbonate of copper."

passed into the hands of the Ontario Mineral Lands company, by whom it was worked till the beginning of 1884, when a depth of 1,230 feet had been reached and silver to the value of $3,250,000 had been extracted. The vein in the part worked would average about 8 to 10 feet in thickness, although in some places it measured from 20 to 30 feet. Its course is north 32° to 35° west, and it intersects a dyke of trap (diabase) running east-north-east, which cuts the dark shales and other nearly horizontal strata of the Animikie formation. The silver was found only in and near the trap, which no doubt had something to do with its concentration at this place. Its deposition also appears to have been influenced by graphite, which was present in the richest parts of the vein. Hydrocarbon gas and water holding chlorides of sodium, calcium and magnesium were struck in the deeper workings of the mine. Graphite and inflammable gas have since been met with in other silver mines in the district. The Silver islet vein is easily traceable across Burnt island and upon the main shore opposite, but it was not found sufficiently rich in silver to be worth working except at the islet.

Description of the vein.

The discovery of silver-bearing veins in the Rabbit and Silver mountain districts about 1882 was due to an Indian named Tchiatang who had worked with the writer in the Thunder Bay district and around lake Nipigon in 1869. He is a native of unusual intelligence, and after observing our operations and making many enquiries about veins, etc., he developed a strong ambition to prospect for minerals. While exploring in the neighborhood of Rabbit mountain he discovered the vein which was afterwards worked there, but on account of an Indian superstition* he would not personally point it out to a white man. Mr. Oliver Daunais had married his daughter, and he got over the difficulty by taking him nearly to the place and explaining where he would find the vein. He afterwards revealed in the same way other discoveries which he made in this district, and these have led to all the present developments, so that the latter are indirectly due to the operations of the Geological Survey. Several mines in this part of the Animikie area have been successfully worked and have yielded large amounts of silver, the most conspicuous examples being the Rabbit Mountain, the Beaver, the Badger and the West End Silver Mountain, but as these are all described along with the other mines of this section in another part of the present report they require no further notice here.

Discovery of Rabbit and Silver Mountain veins.

Other silver mines.

Geologists and miners have speculated a good deal as to the source of the silver and the conditions which have influenced its deposition in certain parts of the veins cutting the strata of this formation. Some, like Mr. Peter McKellar, suppose it has come up from the Huronian system below, and they instance the 3 A mine as an example of the occurrence of silver in a vein traversing these rocks. Others suppose the upper parts of the formation to be the parent rocks. The silver appears to be most abundant in those portions of the veins which lie immediately under existing trap beds or their former extensions, or, as at Silver islet, in a dyke of the same rock, and this would favor the idea that the metal has been in some way

Origin of the silver.

* Indians believe that if they show a discovery of valuable minerals to a white man they are sure to die within one year.

derived from the trap. If this be the correct view we may look for silver in the veins under trap beds in the lower as well as in the upper parts of the formation. Indeed this appears to have been demonstrated in the case of the rich ore at the Thunder Bay mine and in veins recently discovered in the Whitefish lake region, both of which are in the lower portions. In these instances the characters of both gangue and ore are the same as in veins higher up in the formation, as if the nature of their contents depended more on the overlying trap layers than on the immediately enclosing rocks. The enrichment of the 3 A vein may have been due to the infiltration downward of the silver from Animikie rocks, which once covered this spot as they still do the immediate vicinity, but which have since been carried away by denudation.

NIPIGON FORMATION.

General characteristics.

A voluminous set of rocks to which this name was given by the writer in 1872 is found in the lake Superior region, resting apparently unconformably upon the Animikie formation. It is characterised by reddish marls, sandstones and conglomerates, together with a large proportion of variously colored trappean beds and masses, a considerable part of which is amygdaloidal. It is largely developed on Black and Nipigon bays, around lake Nipigon and on Michipicoten island and the promontory of Mamainse (more correctly Namainse). The Keweenawan, or native copper-bearing rocks of Keweenaw point, on the south side of lake Superior, and of Isle Royale, appear to be of the same age. On the north shore native copper has not yet been discovered in such large quantities as on the south side. Its relative scarcity may be due to the less disturbed condition of the rocks on the former. On Isle Royale and Michipicoten island, where the dips are highest, the metal has been met with in the most promising quantities. In the Keweenaw point region the metallic copper has been found as large masses in veins cutting trappean beds, and at the Calumet, Hecla and Tamarac mines in the form of grains and straggling masses of all sizes, filling the interstices of a reddish arenaceous mixed breccia and conglomerate bed, in which many of the fragments consist of red quartziferous porphyry.

Keweenawan rocks.

Native copper on lake Superior.

On the north shore.

Native copper has been met with, principally in veins, on St. Ignace, Simpson's and Battle islands. On Michipicoten island it occurs as grains in an arenaceous ash-bed, while at Mamainse it is found in the form of straggling masses and thin sheets in calcspar veins. But the rocks which have been classified as the Nipigon formation are not alone copper-bearing, but contain other metals as well, and they differ in this respect in the several regions in which they are developed. For example, the lead-bearing character of the red marls and associated rocks to the north-west and north of Black bay is their most important feature from an economic point of view. No metallic ores of any consequence have yet been discovered in the rocks of this formation around lake Nipigon.

Lead in Nipigon rocks.

Little Pic river.

On the west side of Little Pic river certain trappean strata, distinctly bedded and dipping regularly to the south-westward at an angle of about 12°, may belong to this formation, if not to the Animikie. One bed is amygdaloidal, but all the others are crystalline and of different shades of

color. These rocks may have a thickness of 600 feet, and they occupy a space of about eight miles along the river and fourteen on the lake front. On the west side of the mouth of the river horizontal beds of siliceous magnetic iron ore occur in these rocks. The united thickness of three of them appears to be about ninety feet. The percentage of metallic iron contained in the ore from this locality was found to be as follows: by Dr. Hayes, of Boston, 36; by Dr. Girdwood, of Montreal, 46; and by Dr. T. S. Hunt, 37, chiefly as silicate.

Siliceous magnetite.

In the region extending from Thunder bay to Nipigon bay, and thence northward, the strata of this formation consist of the following rocks in ascending order: white grits (seen in the cliff along the south-east side of Thunder bay), red and white sandstone with conglomerate beds, the pebbles being mostly of jasper in a sandy matrix of different colors, compact argillaceous limestones, shales, sandstones and red indurated marls, red and white sandstones with green spots, and red and white conglomerates interstratified with trap layers. These are covered by an enormous amount of trappean overflow crowning the formation, and amounting to from 6,000 to 10,000 feet in thickness. The lower portions of the overflow are usually massive and crystalline, but it becomes more amygdaloidal towards the top. Much of it consists of columnar basalt, but varieties of pitchstone also occur. This volcanic portion of the formation is well developed on St. Ignace and Simpson's islands, and also about point Porphyry. The amygdaloids contain agates and quartz, prehnite, epidote, specular iron, various zeolites and native copper. Concentric wrinkles on the surface of a trap bed on St. Ignace island show that a flowing movement took place in a north-easterly direction, while on the east side of lake Superior similar wrinkles mark an easterly motion of the molten trap. Flow-wrinkles of the same kind occur at the Calumet mine on the south shore. Dykes of greenstone are very numerous in the upper part of this formation. They run parallel to one another in two principal directions, and they all have a transverse columnar structure. There are also many dykes of porphyry in these rocks.

Rocks of Nipigon formation.

Trappean overflow.

Concentric flow-wrinkles.

Dykes.

The crowning overflow of columnar trap on Thunder cape, Pie island, McKay's mountain and all the other hills between the Kaministiquia and Pigeon rivers looks quite like that resting on the red marls of Nipigon bay, Black Sturgeon river and lake Nipigon, and no geological distinction between them has yet been pointed out.

Trap of Thunder cape, McKay's mountain, etc.

The lower members of the Nipigon formation occupy most of the peninsula between Thunder and Black bays, and extend northward up the valley of the Black Sturgeon river to lake Nipigon and around this sheet of water. The grey sandstones, indurated red marls and variously colored compact limestones are well developed in the township of Dorion and to the westward of it. In the north-western part of this township a fault running east-north-eastward has let down the red marls on its south-east side against Laurentian gniess on the north-west. A well defined brecciated vein of quartz, calcspar and barytes, holding galena and a little copper pyrites and blende, has been traced for more than two miles on and near the junction of the two rocks. It varies from fifteen to twenty-five feet in width and is very

Geographical distribution.

Lead veins in Dorion township.

conspicuously exposed, owing to its standing the denuding agencies better than the enclosing marl. The locations of Mr. C. J. Johnson and J. S. Turnbull are situated on this vein. The Malhiot vein runs nearly parallel to the last, at a distance of about three miles to the south of it. It cuts crystalline trap rocks resting on nearly horizontal compact limestones and grey sandstones. Its width varies from six to eight feet, and towards the western part of its outcrop it is well charged with galena in a gangue of of calcspar, quartz and barytes. A large lead-bearing vein, also parallel to the two above described, crosses the lake at the head of Wolf river. It cuts Laurentian gniess in the valley under the marls and trap which form the cliffs on either side of the lake. Another lead-bearing vein, which has been styled the Ogama, is reported in Dorion about five miles south-west of the Malhiot.

Malhiot vein.

In May, 1865, Messrs. Peter and Donald McKellar discovered an important vein of galena cutting the indurated red marl of this formation at a place about three miles west of Black bay, on what is now called lot C in the township of McTavish. The property has been successively named the North Shore, Lead Hills and Enterprise mine. The vein runs about north 60° east, and the red marl is here associated with grey sandstone; but red granite, which is largely developed in this region, rises as a low bluff about 300 yards to the north of it and was encountered at a moderate depth in working the vein. The gangue is quartz, calcspar and barytes, and the total width of the vein is from six to eight feet, of which from three to four feet consisted for some distance of solid galena with a little copper pyrites and vein matter. The mine was worked for one year, and a considerable quantity of rich ore was shipped to the United States. According to assays made by Prof. Chapman it contained an average of $17 worth of gold and $2 worth of silver to the ton.* A vein carrying galena has been discovered in the Nipigon rocks between Pearl River station on the Pacific railway and the shore of Black bay. More than forty years ago Sir William Logan found galena in the rock of Granite island in Black bay.

Lead veins near Black bay.

Crystalline columnar traps similar to those which overlie the red marls, etc., of Nipigon bay are largely developed around lake Nipigon, where they lie for the most part horizontally, and form the prominent bluffs and islands which give rise to the picturesque scenery of the lake. Compact limestones and grey sandstones are found under these traps in several places, and in the hill just behind Nipigon House, on the west side, a stratified red felspar rock, studded with grains of vitreous quartz and having a probable thickness of about a thousand feet, dips north-north-west at angles varying from 40 to 60°. A massive rock, but of a similar lithological character, occupies the lake shore from Nipigon House to English bay, a distance of three miles.† This rock resembles the red quartziferous porphyry, which forms so many of the pebbles in the native copper-bearing conglomerate of the Calumet mine.

Lake Nipigon.

Michipicoten island may be described in a general way as consisting mainly of trappean beds, dipping about south-by-east at an angle of 30°.

Michipicoten island.

*Dr. Bell in Geological Survey Report for 1869, p. 359, and for 1872, p. 108.
†Report of Geological Survey for 1871, p. 103.

Along its northern shore they are mostly amygdaloidal, and are here associated with trap-conglomerates and red sandstones and shales, passing below the trappean mass to the south. Approaching the southern side the ordinary varieties are overlaid by compact reddish trap, sometimes rendered porphyritic by crystals of red felspar and white quartz. Along the south side the trap becomes black and has a resinous fracture. In this part of the island there are some amygdaloidal beds, with fine agates suitable for ornamental stones. The whole thickness of the strata on Michipicoten island probably amounts to about 12,000 feet. On the western end of the island a mine has been opened on a bed carrying native copper, which is so fully described in the evidence of Mr. Joseph Cozens that no further notice of it is required.

Mine of native copper.

The promontory of Mamainse on the east side of lake Superior is occupied by rocks of the Nipigon formation. They comprise a variety of amygdaloids, volcanic tufas, felsites, cherts, sandstones, coarse conglomerates and crystalline traps. The dip is to the westward, or into lake Superior, at an average angle of 45°. At a moderate calculation the thickness of the strata on this promontory would amount to 22,400 feet. The conglomerate bands form one of the most striking features of these rocks, both on account of their coarseness and the thickness of the beds. Five of them occurring among the amygdaloids, tufas and crystalline traps south of Point aux Mines measure respectively about 260, 85, 70, 80 and 450 feet. Most of the enclosed masses are well rounded and smooth, and from the large size of many of them these beds may be properly called boulder conglomerates. They consist principally of dull reddish granite and greenish and greyish Huronian schists.* Nipigon rocks, like some of those on Mamainse, are met with at Batchawana bay, and a small patch of them at Gros Cap at the outlet of lake Superior.

Promontory of Mamainse.

Boulder-conglomerates.

Batchawana bay.

On the east side of Hudson bay and the islands lying off that coast volcanic and sedimentary rocks are largely developed. They comprise reddish conglomerates and sandstones, lead-bearing limestones, chert-breccias, black shales, grey quartzites, dark argillites, porphyries, crystalline traps, amygdaloids, tufas, etc. The upper parts of this series may correspond to the Nipigon formation and the lower to the Animikie.†

Nipigon and Animikie formations on Hudson bay.

POTSDAM FORMATION.

In Ontario this formation consists almost entirely of hard grey and sometimes reddish sandstones. It derives its name from the town of Potsdam in the north-eastern part of the state of New York, and was called the Potsdam sandstone by the American geologists, who often designated formations by their lithological characters only, as Calciferous sandrock, Utica shale, Medina marl, Niagara limestone, etc. It frequently happens, however, that in the extension of strata into other regions their character changes, or they include beds for which the original lithological name would not be suitable. Sir Wm. Logan therefore considered it better to apply the term formation in all cases. The Potsdam formation skirts the borders of the Laurentian area in the counties

Hard sandstones.

Geographical distribution.

*Dr. Bell in Report of Geological Survey for 1876, p. 214.
†See Report of the Geological Survey for 1877.

of Frontenac, Leeds, Lanark and Carleton, and is well exposed in the townships to the north-east of Kingston and in many places between the Thousand islands and the Ottawa river. Its total thickness in this part of the province has not been ascertained, and it is variously estimated at from 300 to 700 feet. Fossils are not abundant in these rocks, and shells of the genus *Lingula* are perhaps the most characteristic. Large trilobites are occasionally met with, and at Perth certain remarkable tracks, supposed to have been made by these animals when the present hard rock was in the state of soft sand, have been found on the surface of one of the beds. Tracks left by creatures of a similar kind were found by the late Mr. Robert Abraham in 1847 in beds of the Potsdam sandstone near Beauharnois, in the province of Quebec. In the sandstones near Perth the late Dr. Wilson, nearly thirty years ago, found a number of long cylindrical casts like tree trunks from six inches to one foot in diamater. Last year attention was called to certain cylindrical bodies of larger size than the above which pass almost at right angles through the sandstone beds of this formation near the Rideau canal about eight miles from Kingston. The only economic materials furnished by the Potsdam formation consist of sandstones for building and glass-making. They are all too hard for grindstones or scythe-stones. The parliament buildings at Ottawa are constructed of Potsdam sandstone from the adjoining township.

Fossil tracks.

Economic. materials

In the lake Superior region the sandstones of Sault Ste. Marie, the peninsula between Goulais and Batchawana bays, Isle Parisienne, etc., seem to be of Potsdam age. They are mostly red, with green spots thickly sprinkled over the bed-planes, and interstratified with greyish layers. Unlike the Nipigon formation, they appear to be free from local disturbances and lie almost flat. Although they resemble some of the sandstones of Mamainse in being red, they are believed to be newer and are probably unconformable to them.

Lake Superior region.

THE SILURIAN SYSTEM.

This system was named by Sir Roderick Murchison after the Silures, a people who inhabited a part of ancient Britain in the border land between England and Wales. It is one of the most important systems in the geological scale, occurring in nearly all quarters of the globe, and is remarkable for the uniform character of its fauna in widely separated countries. It is almost everywhere rich in fossils, which consist principally of the remains of marine invertebrate animals and marine plants, although fishes and some land plants make their appearance in the upper part of the system. These rocks were formerly divided by some geologists into a Lower and an Upper Silurian series. The former is now often called the Ordivician, thus restricting the term Silurian to the upper division. For the present, however, we will retain the name Silurian for the whole system. The Silurian rocks appear to have been deposited during a generally quiet period of the earth's history. They embrace every variety of sediments, and occasionally include some igneous intrusions and beds of volcanic origin. They are divided into a number of formations, and the total volume of the system is very great in most regions. The thickness of each of the formations in Ontario will be given separately.

Extent and character of the Silurian system.

CALCIFEROUS FORMATION.

The name of these rocks is derived from their lime-bearing character. The formation is not important in Ontario, and is found principally between Brockville and Ottawa. It has a thickness of about 300 feet and consists for the most part of a bluish grey magnesian limestone, which has a gritty feel like sandstone, especially on weathered surfaces. The Ramsay lead vein near Carleton Place cuts this formation. Locality of the formation.

CHAZY FORMATION.

This formation derives its name from a town in Clinton county, in the state of New York. It is not an important formation in Ontario, and is found principally in the valley of the Ottawa below Pembroke, and between this river and the St. Lawrence below Prescott. Two outliers occur in the county of Renfrew, one on the Bonnechere and the other on the Madawaska river. It consists of greyish limestones, sandstones and shales, and has a thickness of about 150 feet. Some of the Chazy limestones are very suitable for building, and in certain localities the sandstones are also used for this purpose, but they are generally rather too thinly bedded. Geographical distribution.

BLACK RIVER AND BIRDS-EYE FORMATION.

The formations known under the above names in the state of New York are not regarded in Canada as differing sufficiently, either palæontologically or lithologically, to require separation. The Black River formation derives its name from a stream which enters the eastern extremity of lake Ontario in the state of New York, while the term Birds-eye has reference to the appearance of a fossil contained in the rocks bearing this name. The united formations have in Ontario a thickness of 150 to 200 feet, and consist of bluish and dark grey bituminous limestones with interstratified grey shales. It occurs on some of the islands in the north channel of lake Huron between the Manitoulin group and the north shore. Further east it skirts the southern edge of the Laurentian area from Penetanguishene to Kingston, and it is found in patches in the Ottawa valley above the city of the same name, and as a border surrounding the Trenton basin between the Ottawa and St. Lawrence further east. It is well developed around Kingston, and the building stone of the Limestone City is derived from it. Part of the stone used at Ottawa and Cornwall are quarried from this formation. The lithographic stones of the Marmora and Madoc region also belong to it. Origion of the names. Geographical distribution. Economics.

TRENTON FORMATION.

This important set of rocks is named from Trenton in the state of New York. On lake Huron it is found on Lacloche island and about Little Current in the northern part of Grand Manitoulin island. It occupies a broad belt between Georgian bay and lake Ontario, extending from Matchedash bay to Collingwood harbor on the former and from Newcastle to Amherst island on the latter. Lake Simcoe is situated entirely on this formation, and the whole of the peninsula of Prince Edward is underlaid by it. There is a Trenton outlier in the county of Carleton and it forms the uppermost rock in a geological basin, occupying the whole width of the country Geographical distribution.

between the St. Lawrence and Ottawa east of Ottawa city. The higher parts of the limestone cliffs at the capital belong to this formation. Judging from the results of borings which have been made in various localities, as well as from its general regularity and persistence, the formation is supposed to extend at a moderate but increasing depth south-westerly under the whole of the peninsula between lake Huron on the one side and lakes Erie and Ontario on the other. It has also been shown by borings in Ohio to underlie the newer rocks over a large part of that state. In Ontario it has probably a total thickness of about 600 feet and consists of fossiliferous bituminous limestones, usually dark grey in color, interstratified in some parts with shales which are also often bituminous. It affords excellent building stones in almost every part of its distribution, and it is important as a source of petroleum and natural gas. The oil and gas of the comparatively new field in north-western Ohio are derived from these rocks. The writer has shown that the Cincinnati anticlinal, along which these products have accumulated, continues northward and crosses the western part of the Ontario peninsula, following a line from near Little's point on lake Erie to near Kettle point on lake Huron.* By an inspection of the map it will be seen that Kingsville, where a valuable gas well has been recently struck, is situated on this line. Both the petroleum and gas of this formation have probably originated from the decomposition of the remains of marine vegetation, of which there is abundant evidence in these rocks. The most promising places for boring for either oil or gas would appear to be on the lines of the principal anticlinals, but only where the formation is well covered by impervious strata which have had the effect of confining these products for ages. Surface indications may be entirely wanting.

It underlies the western peninsula.

Petroleum and natural gas.

Cincinnati anticlinal.

Kingsville gas well.

Where to bore for gas.

UTICA FORMATION.

Although this formation is only about 100 feet thick in Ontario it is easily recognised, consisting everywhere of a black bituminous shale. The name is derived from the town of Utica, in the state of New York. It occurs on the northern points of Grand Manitoulin island and on the south side of Clapperton island. It is well seen to the west of Collingwood harbor, and runs thence south-eastward through the country, coming out on lake Ontario between Whitby and Newcastle. The Utica shales are sufficiently bituminous to burn with flame for a short time when thrown upon a hot fire. In October, 1859, works were erected a short distance west of Collingwood for distilling illuminating oil from these shales, which were found to yield from 3 to 4 per cent. of their weight of tarry oil at a cost of 14 cents per gallon. Owing to the discoveries of free petroleum the following year, this enterprise was abandoned. Illuminating oil is, however, still made at a profit from bituminous shale in Scotland.

Geographical distribution.

Shale oil.

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* "The main axis of the anticlinal will intersect the north shore of lake Erie in the vicinity of Little's point in the county of Essex; then running about north-north-east through Essex, Bothwell and Lambton, it will reach the southern shore of lake Huron near Kettle point. Its general bearing from lake Erie to lake Huron is about north thirty degrees east, but it appears to curve gently to the south-east of a straight line and to pass under Petrolia." Transactions of the Royal Society of Canada for 1887, page 107.

HUDSON RIVER FORMATION.*

This formation, named after the Hudson river in the state of New York, has a thickness in Ontario of about 700 feet and consists of bluish drab marls, clays and shales, interbedded with layers of limestone and sandstone. It is met with along the northern part of Manitoulin island and on the south-western side of Georgian bay, and it extends thence south-eastward through the country, widening as it goes, to lake Ontario, on which it occupies the shore from Port Credit to Pickering. An outlier of the formation, eighteen miles in length, occurs in the counties of Carleton and Russell a short distance south-east of the city of Ottawa. The Hudson river formation has furnished no economic minerals of importance in Ontario. The greater part of these rocks were at one time called the Lorraine shales, but that name is now abandoned.

Nature of the formation.

On lakes Huron and Ontario.

Outlier near Ottawa.

MEDINA FORMATION.

The Medina formation is named after Medina in the state of New York. It consists of red with some green marls and a fine grained light grey and sometimes reddish sandstone, called the grey band at the top. In the west the formation first appears near Colpoy's bay, on the south-west side of Georgian bay, and increases to the southward. It has acquired a thickness of about 200 feet in the eastern part of the county of Grey. Continuing thence southward it crosses the country, the thickness still increasing, till it strikes lake Ontario, where it amounts to about 600 feet. Its lower or eastern side comes out upon the lake near Port Credit, and the formation continues thence westward doubling around the head of the lake at Dundas, from which it runs along its southern shore eastward to the Niagara river and crosses into the state of New York. The sandstone at the top of the formation is an excellent building stone, and it is also used for grindstones and scythe stones. This band begins in the township of Nottawasaga, and is found all along the course of the formation to lake Ontario. Some beds of a brownish pink color occurring at the Forks of the Credit are highly esteemed as building stones.

Red marls.

Grey band.

On lake Ontario.

Forks of Credit.

CLINTON FORMATION.

This is named from Clinton county in New York state, and consists in Ontario of greenish and drab grey shales and thinly bedded siliceous and argillaceous limestones of similar colors, amounting to from 80 to 180 feet in thickness, together with a very ferruginous red band which, near Rochester, is called the "iron-ore bed," where it is said to have been used at one time as an ore of iron. The Clinton formation runs lengthwise through the centre of Manitoulin island, along the south-west side of Georgian bay, and thence southward to the head of lake Ontario, from which it strikes eastward along the base of "the mountain" and crosses the Niagara river. In the county of Grey the "iron-ore bed" is bright red and chalky or marly, but near lake Ontario it has become harder and more shaly, and contains a somewhat larger percentage of iron.

Nature of formation.

Distribution.

Iron-ore bed.

NIAGARA FORMATION.

This is one of the best marked of the fossiliferous formations of Ontario. It runs through all the Manitoulin group of islands, the Indian peninsula

* The name of this formation should appear in the table of Divisions of the Rocks of Ontario on p. 2, between the Utica and Medina formations.

and the Niagara peninsula, crosses the Niagara river and ends in Herkimer county in New York. It appears to attain its maximum thickness on Grand Manitoulin island, where the writer estimated it at 450 feet. At Owen Sound it is about 400 and at Hamilton 240 feet. It thus diminishes towards the south and east, while the underlying formations increase in these directions. Except along the Niagara river, where the lower 80 feet consist of bluish black shale, the formation is made up of dolomite or magnesian limestone. Northward of lake Ontario it becomes thickly bedded, of an open crystalline texture and a light grey color, but in the Niagara peninsula it is of a darker shade, closer texture and is more thinly bedded.

Thickness.

Nature of formation.

The Niagara formation is remarkable for the prominent escarpment which marks the lower or eastern boundary in all parts of its distribution. It is a conspicuous feature all along the sinuous course of the base of the formation to the south-west of Georgian bay, and forms the upper part of the Blue mountains in the townships of Collingwood and Osprey, which have an elevation, according to levels taken by the writer, of upwards of 1,200 feet over lake Huron, or about 1,800 feet above the sea. This is higher than the average altitude of the watershed between the great lakes and Hudson bay. From the Blue mountains the escarpment follows a general southerly course to the head of lake Ontario, and from thence it forms the crest of "the mountain" as far as Queenston. The gorge of the Niagara river, into which the falls pour their waters, cuts through the formation, the upper or limestone part amounting to 164 feet in thickness, and the above mentioned shale at the bottom to 80 feet. The Niagara limestone everywhere in western Ontario affords an excellent building stone, and it also burns to good lime.

The Niagara escarpment.

Blue mountains.

Niagara Falls.

At the head of lake Temiscaming, which is situated at the great bend of the Ottawa river, there is a large outlier of this formation consisting of from 300 to 500 feet of grey limestones, with arenaceous beds and coarse or boulder conglomerates at the base.

On lake Temiscaming.

In the northern part of the province, west of James bay, we meet with almost horizontal grey and yellowish-grey limestones, containing fossils, which, according to the late Mr. E. Billings, the celebrated palæontologist, belong to the Niagara formation. These strata occur along the Albany river above its junction with the Kenogami, and also along the latter stream as far up as the first portage. The limestones are overlaid by a considerable thickness of chocolate-colored marls with greenish layers and patches, but without observed fossils.

Near James bay.

GUELPH FORMATION.

This formation, which occurs only in Ontario, was named at the suggestion of the writer after the town of Guelph, which is situated upon it. Its greatest thickness, about 160 feet, is attained in the central part of the western peninsula, from which it diminishes both south-eastward and north-westward, terminating about the Niagara river in the one direction and on the south side of the Manitoulin island in the other. Throughout the greater part of its distribution it consists of a light buff or cream-colored dolomite of a finely crystalline or granular texture, resembling sandstone, but in the Niagara peninsula it becomes dark grey and bituminous, and more distinctly

Thickness and distribution.

crystalline. It is well defined as a formation by a considerable number of characteristic fossils. The Guelph dolomites form beautiful building stones, and they have been largely used for this purpose in Galt, Guelph, Elora and Fergus. They also burn to lime of excellent quality.

Economics.

ONONDAGA (SALT) FORMATION.

This formation is named after Onondaga in the state of New York, and is celebrated for its salt-bearing character. It consists principally of yellowish and drab colored dolomites and greenish and drab shales, with some reddish layers, especially near the base of the formation. It occurs along the east shore of lake Huron from Goderich to the mouth of the Saugeen river, from which it turns east and south, rounding the northern end of a wide synclinal between Southampton and the head of Owen Sound, and running thence south-easterly to the Grand river, from which it takes an easterly course to the Niagara. The numerous borings which have been made through the formation in search of salt in the country to the east of lake Huron prove it to have a thickness of 775 feet at Goderich and 508 feet at Kincardine, but this has diminished to about 300 feet where it crosses the Niagara river above the falls. The beds of rock-salt which furnish the brine of the wells at Kincardine, Wingham, Blyth, Clinton, Goderich, Exeter, Seaforth, etc., occur towards the base of the formation and are only reached by deep boring. The bore-holes for some of these salt wells have also passed through deposits of gypsum. Beds of this mineral occur likewise along the Grand river from a short distance above Paris to near Cayuga. Most of it is of a grey color, useful as a mineral manure, but in some places it is white enough to calcine for stucco and alabastine. One of these localities is the Merritt mine, where there is a bed of white gypsum four to six or seven feet in thickness. Further particulars of these deposits, contained in the evidence collected by the Commission, are published in another part of this report.

Nature of formation.

Distribution.

Thickness.

Salt.

Gypsum.

In this formation on the east side of the Saugeen river, just above Walkerton, the writer in 1861 discovered lithographic stone of excellent quality, but breaking transversely into pieces of too small size to be of much value. The band forms the top of the bank of the river, and the beds associated with it burn into a remarkably white lime.

Lithographic stone.

On Moose river, banks of gypsum occur from ten to twenty feet high, especially on the north-west side below the junction of the Missinaibi, for a space of about seven miles, or from thirty-one up to thirty-eight miles above Moose Factory. About ten feet of the lower part of the deposit consist of solid gypsum of a light bluish grey color, but the upper portions are mixed with marl. In some sections of these banks a comparatively small proportion of the gypsum, but still large commercially speaking, is nearly white, and from this circumstance they have received the name of "the white banks." The geological age of these deposits cannot be far from the Onondaga formation, and it would not be surprising if salt should also be found in the rocks with which they are associated.

Gypsum on Moose river.

LOWER HELDERBURG FORMATION.

Waterline division.

A portion of the Waterlime division of the Lower Helderburg formation of the state of New York reaches the township of Bertie on the Ontario side of the Niagara river, but as it is unimportant and closely connected with the Onondaga formation, it requires no further description in the present short sketch.

THE DEVONIAN SYSTEM.

Old and New red sandstones.

Economics.

Red sandstones.

This system, which derives its name from Devonshire in England, was at one time called the Old Red Sandstone to distinguish it from the Permian, which was known as the New Red Sandstone. Some geologists have advocated changing the name in America to "Erian," but there seems to be no sufficient reason for this, and as Sir William Logan followed the method of calling the systems by their British names and the formations by those adopted in the United States, we prefer to adhere to an uniform plan of nomenclature, and to continue to recognise the well established name of this system. The Devonian rocks are important in various countries, from holding deposits of petroleum, salt, gypsum and iron ore, and they are also of interest geologically from the fact that it is among them that the remains of fishes and land plants first became abundant. Red sandstones form a prominent feature in the Devonshire rocks of the eastern part of the Gaspé peninsula in Quebec, but they are absent from them in the province of Ontario. This system occupies a considerable area in the western peninsula and again in the northern part of the province, and in both of these regions the Corniferous formation constitutes its most prominent member.

ORISKANY FORMATION.

Sandstone.

This is the lowest in the Devonian system, and is represented in Ontario by only about twenty-five feet of coarse grey and brownish sandstone. It is exposed in various places along the base of the next higher formation between the township of Windham and the Niagara river. It has been used as millstones for the preparation of oatmeal, and also for building purposes.

CORNIFEROUS FORMATION.

Distribution.

The Corniferous formation is so called from the nodules of hornstone which it frequently encloses. Its base or lower border runs north-eastward from near Goderich to the township of Greenock, where it turns around the north end of the wide synclinal already referred to, from whence it takes a southward course to the township of Burford, and then strikes eastward to the township of Bertie. The shore of lake Erie from the outlet of the Niagara river to Port Rowan lies upon this formation. Its junction with the overlying Hamilton formation is covered with superficial deposits, but it is supposed to run northward from near Port Rowan, keeping at a distance of twenty to twenty-five miles from the line above described as marking the base of the formation.

Nature of formation.

Thickness.

In western Ontario it consists mostly of grey limestone, containing great numbers of fossil corals, some of which form masses of considerable size. It makes a fair building stone, and is also burnt for lime. Borings for wells in south-western Ontario have given the following thicknesses for limestone sup-

posed to represent the Corniferous in each case: Port Lambton, 320 feet; Petrolia, 248 and 378; one mile south-west of Belle river, 209; Leamington, 310. In such borings, however, it is difficult to draw a line between the limestones of this formation and those of the underlying Onondaga.

The petroleum of the Enniskillen field is drawn directly from the Corniferous limestone, but it has not been proved that it originated in these rocks. There are reasons for supposing it to be quite as likely that the oil comes up from the underlying Trenton formation.* Petroleum.

In the region south-west of James bay the Corniferous formation occupies an area greater than all the western peninsula of Ontario. A large part of this, lying between the Albany river and the basin of the Moose river, comes within the northern part of the province. It consists mostly of porous and cavernous drab grey and yellowish grey fossiliferous limestones resting directly upon the Archæan rocks to the southward, the line of junction cutting the Missinaibi river just below Hell-gate, the Mattagami just below the Long Portage, and the Abittibi just below "The Otters" portage. Many of the Corniferous fossils of this district belong to species which differ from those of the formation in regions to the south of the height-of-land, tending to show that there was here a separate basin in these early times as well as now. At the foot of Grand rapid on the Mattagami river the writer, in 1875, discovered a large deposit of rich clay-ironstone in these rocks.† The materials of the Drift, for a considerable distance to the southward of the Corniferous formation in this region, contain fragments of this ore, indicating that it exists, and probably in the same horizon, among these rocks in many other places besides the above mentioned locality on the Mattagami. James bay region. Clay ironstone.

HAMILTON FORMATION.

This is not called after the city of Hamilton, but a village of the same name in the state of New York. It consists of bluish and drab grey clays or marls, called "soapstone" by the well-borers, with some greyish limestones, and occasionally an arenaceous band. The total thickness of the formation in Ontario is estimated to be about three hundred feet, of which the lower 170 or 185 feet are found below the Drift clay and above the Corniferous limestone in the oil territory of Enniskillen. This impervious rock has served to prevent the upward escape and loss of the petroleum and gas of this region in past ages. Nature of formation.

CHEMUNG AND PORTAGE FORMATION.

This is represented in Ontario by a few feet of black bituminous shales in the southern part of the county of Huron and the northern part of Lambton. A narrow border of the formation may also exist beneath the Drift on the north shore of lake Erie, between Rondeau and Port Talbot. In the states of New York, Pennsylvania and Michigan these rocks are, however, extensively developed, and constitute an important formation. Black shales.

*"The Petroleum Field of Ontario," by Dr. R. Bell in the Transactions of the Royal Society of Canada for 1887, page 109.

†Report of the Geological Survey for 1875-76, page 321.

THE POST TERTIARY SYSTEM.

The Post Tertiary period.

The rocks which have been described in the foregoing pages comprise all the ancient or fundamental formations represented in Ontario, the remainder of the geological scale which is so largely developed in various other parts of the world being entirely wanting till we come to the Post Tertiary period, which includes our superficial deposits such as boulder-clay, stratified clay, sand, gravel, etc. The oldest of these is called the Drift.

THE DRIFT.

Evidences of glacial action.

In a previous part of this section a description was given of the extensive glaciation which took place in the Archæan regions of Ontario during the Drift period, so that it will be unnecessary to dwell further on that part of the subject. The glacial phenomena are also very noticeable throughout the Palæozoic districts, so that everywhere in the province the surfaces of the solid rocks bear the ancient ice-marks in the shape of flutings or furrows and grooves or striæ. With the exception of the high lands near the east coast of Labrador, no part of the Dominion on this side of the Rocky mountains, as far as known, appears to have escaped the action of glaciers in the Drift period. The rocks in the Archæan districts are everywhere ground down and rounded, the evidence of the glacial action being usually as plain on the tops and sides of the hills as in the valleys. In the Palæozoic regions, where the strata lie almost horizontally, the wearing down of the rocks has taken place principally along the planes of bedding. Where the dip happens to be in about the same direction as that which was taken by this great denuding force, the excavations naturally deepened until a point was reached where the weight and solidity of the opposing rocks became sufficient to resist the ice-mass, and in this way escarpments have been formed. All the great lakes of the St. Lawrence, except lake Superior, lie in basins of erosion which have been hollowed out in the same manner. The basin of lake Superior, although its origin was of volcanic nature, has been much enlarged by glacial denudation. It has been shown that the lakes of our Archæan regions are all of glacial origin, and that most of them lie in rock-basins excavated during the Drift period. A few of them owe their existence to moraines or dams of glacial debris, which hold up their waters.

Escarpments, how formed.

Origin of deep bays.

The fracturing of the sedimentary rocks along anticlinal lines has greatly aided glacial erosion, and in this way long bays have been formed in the geographical outlines of the formations, such as those on Manitoulin island, the Indian peninsula and thence to lake Ontario, and all along the base of the Black River formation from Matchedash bay to Kingston.

A marked difference is observable in the effects of glacial action on the opposite sides of the Archæan nucleus on which the Palæozoic strata rest. Valleys or water channels have been formed wherever the ancient glaciers plunged downward off the Archæan highlands upon the opposing edges of the newer rocks, as all along the southern boundary of the Laurentian and Huronian rocks of the province. But no such action took place when the glacial mass was forced up the gentle slope of the Palæozoic beds of the basin of Hudson bay and thence upon the Archæan plateau to the south of it.

Here we find no physical features to mark the line of contact between the two kinds of rock which differ so much from one another. On the east side of Hudson bay deep channels and valleys with high escarpments facing inland have been formed by the descent of the old west-moving glaciers against the up-turned edges of the Cambrian rocks along that coast, while on the opposite side of the bay they moved off the Devonian and Silurian rocks without leaving any impression on the geographical features of that region. Effects of the ancient glaciers.

In the metamorphic regions in the northern parts of Ontario, the rounded glaciated surfaces of the tops and sides of the hills have been left almost or quite bare in many parts, but in most districts and especially in the Palæozoic areas of the province the smoothed and grooved or striated rock-surfaces are covered by a thick deposit of stiff clay mixed with sand, gravel, stones and boulders. This is known as drift, boulder-clay, hard-pan, etc. In Scotland it is called till, and this convenient name is now being adopted in America and elsewhere. On the higher grounds north of lakes Superior and Huron there is usually but little clay, the drift consisting of loose boulders, stones, gravel and sand. Drift in the metamorphic and palæozoic regions.

The transportation of the boulders in the till, as well as those lying on bare surfaces, has been simultaneous with the planing and grooving of the rocks, and due to the same cause. An erroneous impression which is very prevalent attributes both these phenomena to icebergs. Although the latter may have brought some boulders and dropped them among the Post Tertiary clays and sands, they appear to have had little influence on the formation of the underlying till, and they have had nothing to do with the wearing down and grooving of the solid rocks. The ice-grooves are locally nearly parallel, except in cases where different sets cross one another. In pursuing their course they will go up one side of a rounded ridge or knoll of rock and down the other, or they may curve around it and even pass under overhanging rocks, grooving both the wall and roof in a manner quite impossible to have been produced by a floating iceberg. The glacial phenomena of the Drift period in these latitudes correspond in every way with what may be observed on a small scale in connection with modern glaciers, and there can be no doubt that they have been due to land ice. These phenomena occurred at this period in the north temperate zone all around the globe, and the gigantic scale on which they operated constitutes one of the most extraordinary phases of the earth's history. The prevalence of ice was so general at this time that it is also known as the Glacial Period. Glacial phenomena.

The general direction of the glacial movement over Ontario, as shown by the striæ, was southward, but it varied greatly to the east and west of south in different regions. North of lakes Huron and Superior, and from the latter westward to Lake-of-the-Woods, it was generally south-westward, but in some instances it varied greatly from this on account of local causes. In the western peninsula it was south-eastward, but around lake Ontario south-westward; in the lower Ottawa valley south-eastward, but north of it the direction was south-south-westward. In the Eastern Townships it was south-eastward, while around Montreal the course was south-westward. Direction of the glacial movement.

Local causes influencing the course of glaciers.

The striæ following the above courses may not have been all produced at the same time and by a continuous glacier. The ice-sheet would probably move in different courses in different parts, according to the general slope of the surface on which it rested, or according as it accumulated in one part and the resistance became relieved in another. When the maximum had passed, the more its mass diminished the more it would be influenced by the local form of the land. Finally, when it became divided into separate glaciers, these would follow the valleys or would be guided by their confining ridges. Hence in the bottoms of many valleys we find the striæ parallel to their general thread. There is reason to believe that the relative levels of some parts of this continent have changed considerably since the Drift period, and this circumstance must be taken into consideration in connection with the formation and the movements of the ice-sheets of glacial times.

Lateral and terminal moraines.

The local or final glaciers of the period sometimes ploughed their way into the mass of till which had been left by the more general one. They also left behind them lateral ridges or moraines of boulders and earth. Some fine examples of these are to be seen on either side of the southern part of Long lake, north of lake Superior, and along the upper parts of the valley of Steel river in the same region. In some cases the ancient glaciers also left terminal moraines, and these by damming up the waters have formed some of our smaller lakes in the north country.

Material of the drift.

At any given locality the greater part of the materials of the drift usually consist of the debris of the rocks immediately underlying it, but it generally also contains a large amount of transported material, the percentage diminishing about in proportion to the distance from which it has been carried, the harder rocks surviving the wearing action the longest, and thus travelling the furthest.

Clay, sand and gravel strata.

On the generally lower levels of the province, and in local depressions elsewhere, we find stratified clay, sand and gravel resting upon the till. These sands and gravels are usually above the clay. It is supposed that the cause of this was a submergence of the land after the Glacial period, during which the clays were deposited, and as the land rose again the sands were spread over them, and that both deposits were worn into terraces during stationary intervals while the general elevation was going on.

Marine fossils in districts of drift.

In the eastern and northern parts of the province some of the clays and sands contain sea shells and other fossils, indicating a marine origin. In the valley of the St. Lawrence these are found as far west as Brockville, and along the Ottawa they extend about as far up as the junction of the Bonnechère river in clays and sands which constitute continuations of extensive deposits of the same character in the province of Quebec. But no marine fossils have as yet been found in any of the Post Tertiary deposits in the province west of these points and south of the watershed of Hudson bay. The writer has, however, discovered a variety of marine shells on the Albany, Kenogami, Missinaibi and Mattagami rivers up to heights of about 300 feet above the sea level and more than one hundred miles inland.

West of the points above mentioned, south of the height-of-land, the marine deposits are replaced by others which appear to be in part, at

least, of fresh water origin. One of the most important of these is an extensive blue clay deposit which we have called the Erie clay, and which has as yet yielded no organic remains of any kind. It burns to white bricks, while the marine clays to the east burn red. The Erie clay is often very calcareous, and is seldom or never entirely free from pebbles and stones, more or less thickly disseminated through it. Indeed it often seems to merge into the underlying boulder clay. It covers the whole of the south-western part of the western peninsula, and is locally developed in many other parts of the province as far east as the line of railway from Brockville to Ottawa. Its greatest known depth is about 200 feet, but it is found at differences of levels amounting to 500 feet. When seen in fresh section it presents lines of stratification, and often a transversely jointed structure. In some localities its upper parts have been unevenly denuded before the deposition of the next higher formation, which consists of brownish clay yielding red bricks. This unconformable formation is well developed in the valley of the Saugeen river, and hence it has received the name of the Saugeen clay. Its thickness appears to be less than that of the Erie clay, but it is found in broken areas in all parts of the province except the most easterly and northerly. When seen in fresh section it is usually found to be very distinctly stratified in thin layers, sometimes with partings of fine sand between them. Beds of sand and gravel are occasionally found between the Erie and Saugeen clays, and these are of importance as affording good wells of water. Fresh-water shells have been detected in a few instances in the Saugeen clay.

The Erie and Saugeen clays.

The sand deposits overlying the Saugeen clay in the southern parts of Ontario are too irregular and varied in character to admit of classification for the present. But in the district of Algoma and between the great lakes and the Ottawa river a yellowish sand, to which the name of the Algoma sand has been given, is extensively distributed in the more level areas, while on the higher grounds are found considerable accumulations of gravel, stones and boulders, which have been already referred to. Deposits of clay resting on sand with clay again beneath are found over large areas in the extensive and comparatively level tracts beyond the height-of-land. These regions have been explored and reported upon for the provincial government by Mr. E. B. Borron, who has paid much attention to their surface geology.

Algoma sand.

In the western peninsula there is a remarkable and very extensive accumulation of gravel above or west of the Niagara escarpment, which extends from near Owen Sound to Brantford. It has been called the Artemesia gravel, after the township of that name, and consists principally of the debris of the Niagara and Guelph formations, with some pebbles and boulders of Laurentian origin. The gravel, which has a considerable depth, is well rounded, often washed clean of finer material, and is extensively used for road metal.

Artemesia gravel.

From an economic point of view the superficial deposits are important in relation to water supply, the nature of the soils which they afford, etc., and many of the clays have a direct value for the manufacture of bricks and drain tiles. The shell-marls and peat among the recent deposits also belong to this part of our subject. Lignite, associated with clay and sand, is found on the

Economics of the Drift.

Goulais river, and indications of it have also been met with on Rainy river and the southern part of Lake-of-the-Woods. North of the height-of-land the writer has found beds of this substance associated with the till and the overlying deposits in several places on the Missinaibi river, and also on the Kenogami.

Extracts from the evidence of witnesses examined by the Commission bearing on the geology of the province are appended to this section, in accordance with the general plan of the Report.

EASTERN ONTARIO REGION.

Actinolite in Hungerford and Elzevir.

Charles Taylor—We get actinolite within a distance of two and a half to four miles from Bridgewater; there is some in the 2nd concession of Hungerford, and there is some on lot 7 in the 2nd concession of Elzevir. I know where there is plenty of it, but the greatest deposits are in those places; it is in pockets in a magnesian rock associated with dolomite. It appears in forms like veins, which run crosswise of the country rock. We find it at the surface, but have never been successful in following it to any depth; it appears to be in pockets and runs out.

Occurrences of magnetic iron ore and plumbago in Bedford.

Joseph Bawden—The magnetite in Bedford is found against crystalline limestone, with hornblende on one side and hornblende or granite on the other. In one occurrence the hornblende is on the north and the crystalline limestone on the south. At Black lake we have the granite on the north side, and I think crystalline limestone on the south side, but I cannot speak positively as to that as it is under water. The granite in Bedford is, I think, mostly on the north side. The course of the iron deposits is north-east and south-west. Some years ago a shaft was sunk 30 feet, and a drift of 30 feet was opened on lot 2 in the 6th, and about 100 barrels of plumbago were taken out and shipped to the United States, since which time no work has been done and no plumbago has been mined for export. The plumbago occurs kidney shaped, and in round nodules in crystalline limestone in a well defined vein fully three-quarters of a mile in length and 10 feet wide; the walls are limestone. The gangue is crystalline calcspar occuring in crystalline limestone. The vein is defined by a little band of hematite, a gossan streak on each side of the vein; it is just like a ribbon. I take it to be a true fissure vein. The limestone in the vein is coarser, and it is plumbaginous, the plumbago being diffused through the vein as mentioned. The nodules are from a quarter of a pound to five pounds weight. The plumbago is of very good quality.

Iron ore in the Kingston and Pembroke district.

Michael Grady—The iron deposits of the Kingston and Pembroke region are usually found in belts the general run of which is north-east and south-west, about the same as the ordinary run of the rock. The associated rock is granite, and where we find limestone coming in contact with it we always consider the indications favorable for iron. The largest deposits I found were where the limestone and granite came in contact. We have found some soapstone on the surface, but as a general thing it is down deep. I have found some connected with diorite. It is difficult to account for its occurrence when hardly any two experts will agree; each seems to have his own idea. I never noticed any ranges of greenstone rock. The rock in this country varies very much. In building the railway in a cutting of two or three hundred feet four or five different kinds of rock would be found, such as limestone, red granite and black granite.

Iron ore in Darling.

William Rattle—There is no question but they have the true formation for ore-bearing rocks in Darling. We found specular ore in several places on the range. In one place we were shown a vein of magnetite 35 feet in width. At another place we saw hematite at least 15 feet in width, and in length we traced it 200 feet. I should judge from appearance that it was a very good quality of ore; it had no appearance of sulphur or titanium. That was at Playfairville. The course of those veins is north-east and south-west, dipping about 75° to the south-east.

Iron ores in the Haliburton district.

C. J. Pusey—The course of iron deposits in the Haliburton region is north-east and south-west. I have carefully observed the shores on the north and south sides of Burnt river, and they differ essentially. On the south side it is an open, granular ore of the hematite or specular kind, while that on the north side is a magnetic ore of close grain and smooth fracture. A number of specimens analysed by Professor Chapman, taken from various locations on the north side of the river

over a distance of fifty miles, were so uniform in their character that they were supposed by the analyst to be taken from one location. Ores have been discovered at eight or ten different points between the north-east corner of the township of Glamorgan and the village of Bancroft, in the township of Dungannon, a distance of nearly forty miles.

George Richardson—In the Kingston district the phosphate occurs in limestone veins in granite, the phosphate occurring in irregular masses in it. I have noticed phosphate at Haley's, and it is about the same formation. Mr. Smith's mines are irregular ; the work is done the same as in a quarry, there being enough phosphate between the layers of granite to make it pay. In Loughborough a great deal of the phosphate is found in connection with pyroxene rock ; the pyroxene sometimes mixes with the phosphate and makes it valueless. Sometimes crystalline limestone is mixed with the phosphate in the same way.

Phosphate of lime.

Robert Adams—The apatite in the Perth district occurs more in regular seams than in the Ottawa district of Quebec, where it occurs in bunches through the gangue rock. We have traced many distinct veins as much as a mile. They are, I think, mostly across the line of the stratification. Most of them run in a north-west and south-east direction, but there is a good deal of irregularity about them. The country rock is uniform, and consists largely of pyroxene. There is also a great deal of quartz in that country, and pink calcspar. In some cases we find veins in the line of the stratification, and we have struck phosphate veins running at right angles. The width of the vein's varies from a few inches to six and seven feet. The greatest depth we have gone there is 100 feet. We find that as we go down the width varies, being in and out all the way down. We see no difference as far as we have observed between the workings at a depth and at the surface.

Length and width of phosphate veins in the Perth district.

James Foxton—At the surface where we found the phosphate on lot thirteen in the tenth concession of Loughborough, it was about two and a half feet wide. It is enclosed in a kind of a hard black rock. On the surface we have stripped the vein about twenty feet, and we have made openings along the course of the vein, which runs across the whole lot. The tendency of the vein was to widen as we went down. At the top it was two and a half feet, at ten feet it was about five feet, then it ran about the same down to about forty or fifty feet, and at that depth it was about ten feet wide. Then it began to narrow till it got to be about four feet ; after that it began to widen again, and continued to widen till we came upon a "horse." After passing that it continued to increase in width till at the depth of 115 feet it is fifteen feet. The shaft is about perpendicular; a bucket will go down without touching anything. Sometimes we come on pieces of hornblende, some of them as large as two by four feet ; the phosphate is all around them and they come out as clean as possible. The phosphate as it comes up is mixed with hornblende and the wall rock, and that is where we have the labor of cobbing it.

Occurrence of phosphate of lime in Loughborough.

James Bell—In the Perth district we find that generally where there is a mixture of mica, very fine and almost like salt, it is an indication that phosphate is there. It is pretty certain to lead to a vein. There is any quantity of this dark mica, but it is in distinct veins ; it occurs on the same lot as the phosphate and within 400 or 500 feet of it. The mica occurs in veins of different widths from about three feet up to nine and ten feet. There are any number of these mica veins, the whole surface being covered with them.

Mica and phosphate of lime in the Perth district.

William Kelly—My lithographic property is in the township of Marmora, being lots nine and ten in the third concession. I think the quarry extends over 100 acres ; it crops up at the surface, and we have sunk about seven or eight feet upon it. I do not know the depth below that. It is on the east side of Marmora lake. The layers are from six to twenty-four inches thick, and as they go down the thicknesses are greater ; it would require to be sawed for the market. It is a pure lithographic stone. It has been tested and pronounced by experts to be equal to the best German. The property is convenient for shipping.

Lithograph stone in Marmora and Madoc.

D. E. K. Stewart—I am interested in a lithographic stone property on lot 7 in the 5th concession of Madoc. It is laminated and there are very large quantities of it. The layers of stone are from two to four and five inches thick. We can get blocks of it of almost any size ; I have taken out some 48 by 36 inches. There is upwards of 20 acres covered with this stone, and it is so situated that it would not be expensive to work.

W. J. Morris—Barytes occurs in Bathurst, North Burgess and North Crosby. In Oso I have seen a perfectly pure vein three feet wide. I have seen it also in good workable veins in North Crosby.

Barytes.

Fire clay at Toronto.

J. D. Dewar—Very good fire clay has been found near Toronto, and there is any amount to be found on any of the creeks. An analysis by Mr. Sperry gave silica 63.05, aluminum 21.06, ferric-oxide, 5.02, water .63. One analysis from the surface showed 2 per cent. of lime, but I think that was owing to fossils. There are hundreds of acres of it past the Humber ; the river runs over it. It resembles a blue clay and they call it shale here. What I am using I find to be very good.

WESTERN ONTARIO REGION.

Salt boring at Seaforth.

Dr. Timothy Coleman—Our well at Seaforth is about 1,120 feet deep. The first 100 feet was through a loose kind of limestone, hard, with soft streaks. At 350 feet we struck a strong flow of fresh water which rushed up to within six or seven feet of the surface. After going to about 450 feet the Guelph limestone is struck. At 800 feet there is a kind of rotten stone of a clay color ; there is about fifty or sixty feet, but about midway is a layer of very hard stone intervening. At 880 feet there is a bed of clay, and after that it is limestone down to the salt, at 1,020 feet. There is a bed of salt at that depth of seven or eight feet. We continued on 101 feet and stopped, as we were in the rock salt and had all we wanted. After coming to the first bed of salt there is a layer of three or four feet of porous rock.

Salt boring at Goderich.

Tecumseh well

International well.

Attrill's well.

Boring at Mitchell.

Dublin.

Brussels.

Peter McEwan—The first well I drilled in this part of the country (Goderich) was in 1868, called the Tecumseh. It was in the town, and the depth was 1,130 feet. The depth of the surface material or drift on the high land is 120 feet, and in the valley 30 or 35 feet. There the surface material is marl, while on the hill it is different. The first 30 feet of the Tecumseh well was quicksand, and below that it was blue clay down to the rock. There was a streak of gravel on the rock below the clay, and a little clay mixed with the gravel. It was a sort of hard pan like cement, varying from 5 to 10 feet thick. The only difference in the wells here is before striking the rock ; after that all are the same. The International well was drilled in the winter of 1873–4. There was no quicksand there; it was clay down about 110 feet. Below that there was a streak of hard-pan about 10 feet, and then a grey limestone rock. The first 50 or 100 feet of the limestone is hard; after that it becomes softer and more broken, and is full of water. After getting through the broken rock the limestone becomes more solid again, and there are nodules of flint in it. At 750 feet we reach blue shale with streaks of blue clay, which continues down about 1,030 feet, where the salt is struck. We suppose that the first bed of salt is about 16 feet in thickness. Below that we have 30 feet of light brown limestone of very fine grain; then a bed of salt about 30 feet, then 4 feet of blue shale, then another bed of salt about 22 feet, below which we found a brown limestone similar to the first. We did not go much more than 15 or 20 feet further, and I think the limestone does not go below that. Before we struck the salt rock itself the shale became salty, no doubt with small streaks of salt. The first salt we struck had small streaks of shale in it, and there are small streaks of gypsum at the bottom of the shale. The purest salt of all is in the lowest bed. In Attrill's well they went down further than we did, and struck two or three small beds below ours; they were very thin beds. At the greatest depth of all they struck a red shale. In 1871 we sank a well in Mitchell 2,000 feet and did not get salt. The material passed through was pretty much the same as here, but there was not such a thickness of limestone. About the depth at which we expected to get salt we got saline water. We got about as much white clay as we get salt here. The surface is about the same as here, but there is about 100 feet of limestone less than here. When down about where the salt should be we met shale the same as here, but softer than ours. There it is more like slate. In Seaforth there is about 200 feet like clay, and in both Mitchell and Dublin where we should have struck the salt we came on the substance like pipe-clay. There was about the same thickness of it as we get of the salt rock here. It was very like the blue clay, only there was the difference in color. I do not think any experiments were made with it. At about 1,200 or 1,400 feet we struck a red or light brown shale which continued to the bottom, 2,000 feet; there would be about 600 or 700 feet of it. That is the deepest well in this part of Canada, that I know of. The salt appears to play out between Seaforth and Dublin. I drilled a well one and a quarter miles east of Seaforth and got salt, but not in large quantity. At Dublin we did not get any salt; there was salt water, but nothing that could be called rock salt. In 1872 at Brussels we went through similar strata, and we got salt water and pumped for three weeks; there was some salt made there, but it was con-

sidered a failure. Another party drilled a well at Wroxeter. I do not know much about the log of that well, but I know they did not get salt. After that another man drilled a well three quarters of a mile south of where we did and within the corporation of Brussels, and he got salt. That shows the town to be on the edge of the salt bed. Of course there is plenty of salt for manufacturing purposes, though not as much as here. The salt was got there a little nearer the surface than at Seaforth. To the north-west they drilled at Kincardine and got salt; at Port Elgin they drilled but did not get salt, as also at Southampton. Mr. Williams of this town owns a well at Port Franks, 40 miles south of here. We can trace the salt bed all the way from here to Marine City in Michigan. At Parkhill they drilled a well and got the same salt bed as we have. The well is a good one but is not being used. At Petrolia also, as well as at Bothwell, they have the same salt bed as we have, but more of it. There it is under the petroleum, and deeper than here. The basin gets deeper and there is more salt towards the south; probably the great basin is under the state of Ohio. The salt rock at Goderich is 950 feet below the level of the lake. At Courtright they have to go down 1,500 or 1,600 feet to get the same salt bed, showing that it dips in that direction, and extends all the way. Across the St. Clair river from Courtright there are two or three wells, and there are several from there south towards Detroit. The whole of that section of the country is underlaid with salt. In sinking wells at Courtright and St. Clair they had the benefit of our twenty years' experience. They drilled their wells on the bank of the river, and that is a grand place for commerce. A hundred vessels pass there for one that comes here, and they can get a great deal cheaper freights. There is no teaming and no labor in loading; the salt is loaded right on the vessels. They can make their salt cheaper than we can. The day is passed when reciprocity in salt would benefit Canada. Salt has not been found at Saginaw, but I think it is there at a greater depth. It is said that a well was sunk near Detroit which went through salt three or four times thicker than ours. At Manistee they got salt, but of course at a greater depth than here. They have been manufacturing it very cheaply there, as from the waste of their sawmills they get all the fuel they need.

The Kincardine district.
Port Franks.
Parkhill.
Petrolia.
Courtright.
Advantages of manufactures on St. Clair river.
Saginaw.
Detroit.
Manistee.

H. Kittredge—I drilled six wells north and south of Glencoe; the deepest was 560 feet. We got a very slight show in that well, so slight that it could hardly be called a show of oil. The character of the rock was very similar to what it is near Petrolia. The first rock we got in all of those wells was black shale; below the black shale we got streaks of limestone, streaks of slate and soapstone, and then a similar formation to that we have here. Generally there were two large veins of soapstone with a layer of limestone between the two, known here as the middle, upper and lower limestone. After that we got into the hard rock which was continuous. Oil could not be found there at the same depths as here.

Oil borings in the vicinity of Glencoe.

Duncan Sinclair—We strike limestone rock here at about 100 feet. In some places it is 35 or 40 feet thick, and there are streaks of soapstone in it. When we go through that we strike about 120 feet of soapstone; it is soft and of the nature of blue clay. Below that is the middle lime. It averages from 15 to 18 feet and is not very hard; it is a kind of a grey limestone. Below that we strike the lower soapstone; it is like shale and there is about 40 feet of it. Then we get 70 or 80 feet of hard lime rock again, harder than the middle lime rock. After we get to 400 feet the stratum is between a limestone and a sandstone, and is soft. That generally runs to a depth of 465 or 480 feet; then we get the oil rock. It is a brown kind of rock, very soft and porous. I have seen some that looked like honey comb. Sometimes we find crevices in it, and the tools drop. The largest wells we had here were found in crevices, but there are no big wells got in the crevices now.

Boring for oil at Petrolia.

Hon. J. Baxter—On the bank of the Grand river four miles south of Cayuga my brothers own a quarry. It is a limestone, but is magnesian and is not good for lime. Under that bed there is a layer of stone that could be manufactured into cement. Some years ago a quantity was burned in an ordinary limekiln. Only a few barrels were made, but it worked as well as the Thorold, and very much like it. The stone is grey and brown in color; a considerable quantity was quarried as building stone and they get blocks from twelve to fifteen inches thick; it has been used at Dunnville. The quarry extends along the bank of the river about half a mile. The stone does not stand the weather as well as the sandstone; it is more liable to crumble. About three miles from Ridgeway there is corniferous limestone. It is extensively used in making lime, and makes a first class article, very white, and about the same quality as the Beachville lime.

Cement stone on Grand river.
Limestone.

LAKE TEMAGAMI REGION.

The region north of lake Nipissing.

Edward Haycock—I am a civil engineer and mine owner, and my residence is at Ottawa. I have explored the country around Cross lake, where I saw galena and copper. The lake is in the Huronian formation, to the north of lake Nipissing. Six miles south of the lake one strikes the Laurentian formation. All the discoveries of minerals in that section occur in the Huronian rocks. I found galena, carrying a good deal of silver, and in the same vein copper and a good deal of gold. The vein was from two to six or seven feet wide. It occurs in the trap rock, the country rock being clay slate. Where the vein runs into the water it appears to be pretty solid; it is about five or six feet wide, and may be seen under the water for some distance. On the island it is very much split up and distributed through various crevices of the rock. Just above Cross lake, on lake Temagami, I saw a great deal of mineral; it was principally on the south-east side of the lake. I saw a great deal of iron pyrites in deposits, but I do not think I saw a vein at all. It was pretty pure pyrites—as pure as I have ever seen it. I had some of it assayed and the reports went from 5 dwt. to 3 oz. and 4 oz. of gold to the ton. Some of the deposits were very large. One into which I put a few blasts I should say was five feet wide, and it has been traced a little over half a mile, all solid pyrites. There is a great quantity there in the vicinity of the lake, but it is too far from a railway. The only hope is that the James Bay railway may go on, and if so it would pass close by. The rock where this pyrites occurs is slate. Some of the deposits are associated with trap; the country rock is clay slate. On the north-east side of lake Temagami are some small showings of copper in quartz veins. The country has never been prospected or examined properly, and no doubt when it is large deposits will be found. The copper is in bunches in the quartz. I saw one vein about two or three feet wide. The islands upon the lake are full of minerals. There is a fine true roofing slate upon that lake, and enough of it to supply the whole continent. The same slate is seen again upon the Matabechawan, which empties into lake Temiscaming upon the Ontario side. The slate is exposed and there is a very large extent of it; it is a kind of grey-green. It splits into all thicknesses, from the eighth of an inch up. I have not seen the iron deposits in that region, but beautiful specimens have been brought to me by the Indians, both of hematite and red specular. The Indians say the deposits are very large. There is any quantity of timber, and that is one of the difficulties in exploring, the timber and moss covering the land. It is small stuff, such as poplar, jack pine, small red pine and white birch. It had once been burned over. The land around the lake is not good for farming; there are a few spots that would make good farms, but only a few; it is nearly all rock—I am speaking of the country just around the lake. From Temagami lake is a stream that empties into the Montreal river called the Temagami branch. There are two outlets from lake Temagami, the Sturgeon which flows into lake Nipissing, and the one which empties into the Montreal river. On that branch I have taken up six claims. On those claims we got galena carrying from 8 up to 64 oz. of silver to the ton. We got copper running from 18 up to 35 per cent., and one assay of galena gave us 54 to 64 per cent. of lead. We also got magnetic iron on the same property. We have one copper vein between ten and twelve feet wide, and galena veins from six inches up to fourteen feet wide. The copper veins are all sulphurous; they are quartz with a little spar. It is yellow copper ore, but there is a good deal of peacock copper in the large veins. Nearly all the veins have more or less copper; there are four in which the copper predominates, and they strike north-east and south-west, the dip being at about an angle of 45° to 60°. All the veins dip the same way and run the same way. We have one vein between 12 and 15 feet wide, which has been traced 200 feet. It runs about 40 per cent. of mineral, in which there is from 6 to 62 oz. of silver to the ton; that is the largest vein. We have gone down about 10 or 12 feet on one or two of the veins; they are in trap, the country rock being slate; the veins cut through the trap. Dr. Bell has seen a couple of them and he says they are true fissure veins. There is no doubt but that it will pay to work some of the large ones. I intend to put on a large gang of men next year; and if the veins prove as good below as they seem to promise, I shall put up a couple of furnaces. We have plenty of charcoal, and all the flux necessary, and we will smelt for silver, lead and copper. We have got traces of gold, but I have not found anything sufficient to consider valuable. I know of a great many other veins, some of which I intend to take up next year, but before doing so I want to put in a couple of shots to see how they look below; if they are good I shall take them up. They are all in the same district. The country is

Minerals in the Temagami district.

Pyrites.

Copper.

Roofing slate.

Iron.

Timber.

Mineral veins north of Temagami lake.

A country full of minerals.

full of minerals there, but what is wanted is practical men to explore it. One man can do but very little in a wooded country like that. I think gold will be found. I have found it in different places, where it ran from 5 dwt. up to 3 and 4 oz. I have found it all the way from Cross lake up to the height of land in connection with copper and other minerals. We saw a great deal of jasper in the conglomerates. The formation is the Huronian. I have got asbestos from half an inch to nine inches long, but I cannot say whether there is much of it as it has not been opened up yet. One of the veins shows about a foot wide ; those are veins in trap, running in the same direction as the quartz veins. In some there appears to be nothing but asbestos, but nothing has been done at all except to scrape off the moss. I suppose there are seven or eight of those veins there. I found asbestos up at the height of land, in serpentine rock. Up the Montreal river I found rich copper too ; there is one vein there which the Indians told me they traced a mile and a half, but I did not go over it. The Indians brought some of the ore to me ; it is very rich. At Round lake we strike a splendid tract of farming land. There are a couple of good Indian farms there now ; it is a kind of loam, a warm soil. The timber is balsam, birch and spruce ; it is all second growth. There is a great depth of soil. I suppose there is between five and six inches of black soil. The subsoil is loamy clay ; take it in your fingers and it will pulverise. That stretch is between 20 and 30 miles long and 6 to 8 miles wide. There is no large timber upon it. The Indians grow splendid crops, potatoes especially, but they do not sow grain at all. I saw turnips there half the size of my hat. I do not know what time the season opens, but I got potatoes on my way down, and when I arrived here they were only coming in. At Matatchewan, still further up, the Hudson Bay company grows splendid crops of barley. There is not much good land around the trading post, but further up the Hudson Bay people tell me there is a still better tract of farming land. The whole of the country from Cross lake to the height of land near the boundary between Quebec and Ontario is a mineral country. It is all in the Huronian formation, except here and there a spur of the Laurentian. I think over the height of land we may strike coal. I have met a good many people who say they have seen it, but I think it is lignite. That country wants a railway, and when it gets it there will be immense mining work carried on. The mineral is there ; mineral that will pay to move. What is wanted is a railway ; a colonisation road would not answer.

Asbestos.

A tract of good farming land.

Coal.

Railway facilities needed.

J. C. Bailey—I am a civil engineer, and have been employed in railway surveying in this country and the United States all my life. I have explored portions of northern Ontario. I located the Northern and Pacific Junction railway between Gravenhurst and lake Nipissing. I am chief engineer of the Ontario and Sault Ste. Marie railway, and have been all the way through the North Shore two or three times. I have also spent a good deal of time in the country north of lake Huron and lake Nipissing, and I have explored that section of country between lakes Nipissing and Temiscaming. I have just returned from exploring the section of country between lake Nipissing and lakes Temagami and Temiscaming for the Nipissing and James' Bay railway, being chief engineer of that road. We were away on that trip fifty or sixty days. We went in a north-westerly direction from North Bay till we arrived at lake Temagami. We then went easterly toward lake Temiscaming, where the Montreal river joins the lake. Then we turned southerly, keeping to lake Temiscaming, but gradually getting away from it to the Government road. We came right through on the road to North Bay. The general character of the country from North Bay to lake Temagami is rolling land, with a good depth of soil and very little rock. We could see the soil along the streams, and in nearly every case there was about three feet of thick black loam with a clay subsoil. We could tell we were in a good country by the timber. There was very little exposure of rock where the land was good, although along the lakes and rivers there were rounded rocks, but not as in Muskoka. From North Bay to Rabbit lake the formation is Laurentian, but beyond that it is Huronian. In many places the country is covered with moss. In all the flats, however, there is a good extent of soil. On the rounded hills the country is thickly wooded with Norway pine. We also found a good deal of white pine in that region, and some splendid flats of sugar maple, as well as a good deal of black and yellow birch. I measured some of the pine, which proved to be 20, 30 and even 40 inches in diameter. We also observed a great deal of what the lumbermen call the "cork pine," which is the best variety of white pine. In some places it is mixed with birch, but generally the pine prevails. The best pine I saw was on good rich land, a sort of sandy loam. The pine forests are very

Region of country explored.

From North Bay to lake Temagami.

Soil and timber.

thick about lake Temagami and around by Rabbit lake. However, it is almost impossible to transport the timber by water. There are plenty of streams there, but practical lumbermen say there are too many falls to admit of timber being floated down. We went down the Matabechawan, and along that river there is the finest Norway pine I ever saw. I measured a lot of it 36 inches through. Coming down by the Government road from lake Temiscaming to North Bay the land was excellent, but five miles south of Montreal river it was very rough. After that, however, there was a reach of seventy or eighty miles of splendid land. The timber in that region is mainly white pine, black and yellow birch, and there is a large extent of beautiful spruce and tamarac. The largest birch trees I saw were from three to three and a half feet through. They grow to a height of seventy or eighty feet. Out of some of these trees you should get on an average three good logs of say twelve feet in length. The tamarac is sometimes found 24 inches in diameter, but a good average would be 15 or 20 inches. The smaller size, 10 or 12 inches through, is used for ties. There are also patches of good young second growth poplar growing on land that had been burnt. We also found lots of maple, the trees running from 10 to 20 inches through. We saw considerable white ash, growing up to fifty or sixty feet and about twelve inches in diameter, and it commanded admiration. We noticed some whitewood, too, such as formerly grew in the Lake Erie counties ; it grows from 24 to 30 inches in diameter and is very handsome. I may say that we met with these various timbers both going up and coming down. Coming down the Jocko river we found a French Canadian who had settled on 200 acres and had several stacks of hay cut. He had been there only twelve months or so, and had gone into the cattle raising business. Another settler, a German, showed me some immense potatoes he had grown there. There are no settlers on lake Temagami, but the Hudson Bay company have a post on Bear island, which has been established about seventy or eighty years. There are about fifty or sixty persons in the post, including women and children. There is good fishing in the lake, principally whitefish and salmon trout, and various other posts of the company are supplied with fish from there. Potatoes and corn are grown on Bear island. During my whole trip I saw no snow more than three feet deep along the river. An Indian told me that the snow was seldom any deeper, and that the winters were not often colder. The atmosphere is dry, and the cold is not felt as severely as down here. I had not a very good opportunity of examining the country for minerals, it being winter, but there were indications of hematite iron on Tomiko river, and I was told by an intelligent Indian named Bocage, who was hunting with me, that there was lead also. I also noticed some quartz veins in the rocks. The Indians told me that there was copper all around Temagami, both east and west, and we had specimens of lead and copper from that region. There has not been much exploration, but from the nature of the rocks I believe it must be rich in minerals. Already settlers and investors are turning their eyes toward that region. A couple of weeks ago I wrote a letter to the newspapers describing the country, and a few days afterwards I was informed that several American gentlemen were purchasing maps of that district and making more particular enquiries about the mineral deposits there. I am satisfied that as regards soil and climate that country is well suited for agricultural purposes. Mr. Nevin, who has surveyed the townships north of lake Temiscaming, has said in his report that out of five townships there would not be over 100 acres of bad land. A nunnery has been built there, and there are many French Canadians going in for settlement. In the latter part of February we found the common house fly in our tent, and in March and April yellow butterflies were flying about. We also heard the rosignol, the Canada bird and the swamp robin in the last named months, and crows were very common all through the winter. The country is full of moose ; they are there by thousands. They used to tread the roads so heavily that it made travelling by snow-shoes very difficult for us. We often saw them playing on the ice, and sometimes came across their stamping grounds. We also tracked the cariboo, and the Indians say there are plenty of them. There are red deer there too, and we often came across wolves. There is an abundance of fur bearing animals, such as the beaver, marten, fox, mink and otter.

On Matabechawan river.

A broad reach of good land and timber.

Settlers.

A favorable climate.

Indications of minerals.

Fauna of the region.

SUDBURY REGION.

James Stobie—About three years ago, in 1885, I discovered the Stobie copper mine ; it is on the south part of 5 in the 1st of Blezard. I opened it up and sold it to the Canada Copper Co. I am now interested in a location with a deposit of copper on the north half of 6, in the 1st of Blezard. There has been only a little blasting

Copper discoveries.

done upon it, but there appears to be a very large quantity of ore. There is gold and silver on a property I own on lot 10, in the 6th of Creighton. I discovered it in the latter part of July, 1885, but did not do any work upon it till recently. The principal matter of the vein is iron pyrites, with more or less galena, and some quartz, but not in a solid mass; there is black slate on both sides. The assays, made from specimens taken up at random, showed silver $11 and gold $7 to the ton. The galena is in fine particles, and seems to be mixed with the iron in the vein to a great extent. A slaty rock generally accompanies copper deposits. In Denison the rocks are somewhat similar to what they are at Sudbury, but there are some there that are not here. As a general thing I would follow diorite for copper. I do not think you will get much copper without the diorite. I am told it goes to the gneiss and stops there. The diorite that most people fancy is that near the gneiss, but I do not think the gneiss has much to do with the copper. I consider that in the Sudbury district copper exists in paying quantities, and that there is a large amount of gold in Denison. There is no good iron ore in this range that I have seen; there is too much sulphur. I have found boulders here and further north with good ore. In the country from Killarney to Sault Ste. Marie we find iron between quartzite and diorite; the quality is very good there, and important discoveries will, I think, yet be made in that section.

R. R. Hedley—I have been out on the ground where prospectors had made discoveries, and took samples for myself and found gold. Those lots were in Lorne, and are the only ones I can be sure of. On the surface of one property I found matter that assayed as high as four ounces; from another adjoining that I selected stuff that runs away up in the hundred ounces. In connection with the first there was considerable pyrites; the last was free milling. I have examined many specimens for different parties yielding low results, from two to twelve pennyweights.

Gold in Sudbury district.

F. L. Sperry—I am a chemist, and have been living in this country about three years, engaged in professional work. I think copper and iron exist in paying quantities in this section; nickel seems to occur in the iron. I suppose I have made 400 or 500 assays for different parties all the way from Toronto to lake Winnipeg. The majority from this district were of iron, nickel, copper and sulphur.

Copper, nickel and iron.

P. C. Campbell—I think gold, silver, platinum, zinc, nickel, tin, copper and iron exist in the district between Sault Ste. Marie and Sudbury in paying quantities. Tin has been found in two cases mixed with other ores on the copper range. There were no indications of tin in the first instance, but it was found as the work went down. I cannot say certainly that it will turn out to be in paying quantities, nor can I say that nickel or zinc is in paying quantities; the other metals I have mentioned I think are.

Minerals in the Sault and Sudbury districts.

SAULT STE. MARIE REGION.

Thomas Frood—The sand in the front of the Wallace mine property carries small but distinctly appreciable quantities of gold. In five or six places where Williams, the Cornish miner, dug into the hill, small particles of free gold were found. As yet no large quantity has been discovered. We have not come upon any veins carrying free gold, but we have met with galena mixed with iron in several places. The country rock of the Lacloche mountains is quartzite cut by bands of diorite. In some cases these bands are parallel to the mountain; sometimes they are angling across; and this diorite always shows some metal, generally pyrites. I have been told that in places where the diorite is cut by quartz, free silver and copper have been found. Lumbermen have brought specimens from the north slope of the Lacloche mountains of good galena. In the bands we generally find iron pyrites, copper pyrites, arsenical pyrites, small quantities of specular iron and galena, but no precious metals. During the last few years I have done a great deal of prospecting from the Thessalon to the Mattawa, and from my observations I do not think there is a square mile in that distance in which mineral may not be found in appreciable quantities. Along the shores of the Georgian bay and on to the height-of-land will be found belts of mineral-bearing rock. Within the last eighteen months the country is beginning to be better known, and more prospectors are around than ever before. It is only now people are commencing to recognise the possibilities of this section, and that is the reason that more work has not been done here in the past; but as soon as capitalists fully realise the mineral wealth of the Algoma and Nipissing districts there will

Minerals in the La cloche mountains.

Algoma and Nipissing districts.

be a great improvement. In the past, and even yet, attention has been drawn nearly altogether to the Port Arthur district, and that to a large extent accounts for the overlooking of this section by capitalists. In fact there has been a general apathy displayed hitherto in reference to the resources of northern Ontario. It has been reported for some time that on the south side of the Lacloche mountains, from Killarney to Lacloche, silver exists. Several specimens of silver and copper have been given me by lumbermen as having been found in this range, and I would not be surprised at any time to find silver, copper and possibly gold.

Minerals in the Goulais Bay and Batchawana Bay districts.

R. E. Bailey—At Batchawana bay and Goulais bay we get gold and silver; at Garden river, silver lead; and at Macbeth, copper. Those properties are in the unsurveyed district, and are on Indian lands. We acquired the property from the Government. At Goulais bay we have two shafts, one twenty-six feet and the other twenty feet deep; it is a fissure vein. At Batchawana bay the vein is sixteen feet wide; the gangue is quartz. I have found gold in it that could be seen with the eye, and some sulphurets, including traces of copper. The vein runs north-east and south-west. It is about half a mile inland from Batchawana bay. The Goulais bay location is about three miles north of the north point of that bay. The veins run towards each other. The one at Goulais bay is about fifteen feet wide. The gangue is quartz, containing gold and silver. We have had assays of both with about the same results; gold from $4 to $28, and silver from $2 to $8. The assays were made by reliable men in Milwaukee and in Idaho, with the same results.

Gold and silver in the Sault Ste. Marie district.

Æneas McCharles—I have been looking for the mother lode, which I believe to be somewhere in the district, but I cannot say how far back. On the north-east quarter of 27 in Korah we got gold and copper, which together went $27. That is, taking copper at the price before it went up; there is 6 per cent. copper. I think the gold was from $2 to $4.50. We put some blasts in at the Everett mine, on the south-east quarter of 13 in Prince; it assayed, gold $32, silver $1.16. I have had a good deal of assaying done, and I don't know of any that did not show gold from a trace up. One showed $60; that was from the west of here. All the iron from this section carries more or less silver. There is a four foot vein of galena in a maple bush on the Goulais river, somewhere about 14 in Vankoughnet.

Increased activity in prospecting.

T. A. P. Towers—I think more prospecting has been done this year than for the last twenty-two years, and I do not think it is likely to prove "a flash in the pan" this time. There is no doubt that there is a great amount of mineral in this country, and more interest is being taken now than ever before in this immediate neighborhood. A great many people go to the registry office to get maps, and I know they want them for exploring purposes. I am the deputy registrar.

MICHIPICOTEN ISLAND.

Michipicoten Island locations.

Joseph Cozens—In July last I purchased in conjunction with an American friend the Charles Jones, Bonner and Harbor locations on Michipicoten island. These locations contain altogether about 13,000 acres of land, and a very large amount of money has been spent upon them in improvement and development. The money has not always been judiciously spent, still an enormous amount of work has been done. The expenditure has been chiefly made upon the Charles Jones location, which is situated on the west end of the island. The first work of any consequence appears to have been done about the years 1860-61 by Mr. H. Fletcher on behalf of some New York parties. He sank several exploring shafts and did more or less cross-cutting and drifting, with very encouraging results; so encouraging indeed that he erected a small stamp mill, etc., and produced several barrels of copper. Some trouble that arose about the payment for the machinery resulted in its being seized and taken away. In consequence the work was stopped and the property practically abandoned for the time. About 1875 the Quebec and Lake Superior mining association made further explorations, and between that date and 1880 they made large clearings and erected substantial barns and farm dwellings upon the property. At the same time G. A. Phillips, of Milwaukee, Wis., did a considerable amount of exploring on and near the east boundary of the location, sinking several exploring shafts from 90 to 150 feet in depth, and finding heavy copper in all of them. In 1880 the Michipicoten Native Copper company was formed in England with a subscribed capital of $220,000, and work was commenced on a very extravagant scale. During the spring of 1883 the company was reorganised with $100,000 additional capital. After the expenditure of these amounts a further sum

Early explorations.

Working on an extravagant scale.

of $50,000 was borrowed on debentures, and also spent. In the fall of 1884 the company, being heavily in debt, went into liquidation, and the property was purchased in 1885 by the late Mr. Matthew Curtis, then mayor of Manchester, England. Mr. Curtis spent about $70,000 in further improvement and development, when his sudden death in 1887 caused the stoppage of the work, which was being pushed forward with vigor. I had charge of the work for him, and upon the executors to his estate making me an offer of the whole property I purchased it at once, being intimately acquainted with it and fully convinced of its great value. The bulk of the work has been done on an amygdaloidal bed, similar in character to the lode at the Quincy mine on the south shore of lake Superior. At the present time the main shaft is sunk to a depth of 520 feet, Batler's shaft 360 feet, and about 1,500 feet of drifts and crosscuts have been run, opening up a large extent of rich stoping ground. The discovery in 1887 of a conglomerate lode similar in character to that of the celebrated Calumet and Hecla mine has added greatly to the value of the property. This lode is situated about a mile and a quarter to the westward of the main working, and is about 8 feet in width; its course is north-east and south-west, and the dip about 50° to the south-west. A shaft about 40 feet deep has been sunk on the underlie, showing at the bottom a pay streak of about 2 feet carrying 5 per cent. of copper. A number of crosscuts have been made at various depths up to 200 feet by the diamond drill, proving the extent and continuity of the lode and the increase in width of the pay streak as depth is attained. At 200 feet the whole width of the lode carried copper. The timber on the island is chiefly maple, with more or less valuable spruce, cedar, etc., on the lower lands. Cordwood for fuel can be produced at a cost of from $1.25 to $1.50 per cord. All the timber and lumber used in the construction of the various buildings have been cut at the saw mill on the location. On the Bonner location some work was done many years ago—report says on rich veins of native silver and nickel ore. I have myself found nuggets of native silver on the beach in front of the location.

Depth of shafts.

The Bonner location.

LAKE SUPERIOR REGION.

S. J. Dawson, M.P.—Silver is in large quantities, and exists over an extensive area in this country. Iron is in paying quantities, and has been discovered in many places throughout the district. Gold has been discovered and is reported to be in paying quantities in different sections. Zinc blende has been discovered in quantities sufficient to pay for the manufacture of zinc; it is in very considerable quantities, and very generally distributed over the district. Galena is in large quantities throughout the district, especially near Black bay. Building stone of excellent quality is found in different parts of this district, from Verte island to Nipigon bay. Stone of excellent quality, color and texture is now shipped to Chicago and other American ports, and a considerable trade is arising. Granite of fine quality is found in different places. About twelve miles east of here, in McGregor, there is a grey granite very like the Aberdeen. At Jackfish bay there is a stone of a beautiful quality, the nicest I ever saw; it is of dark color, and exists in large quantities. Samples of it have been polished. On the Black river a stone occurs that takes a high polish, and is very beautiful. It is of white color, spotted with crimson, and is of a felspathic character. Molybdenite occurs in considerable quantities at the Black river, but the market is not extensive enough to make it pay at present; the quality is very good and the quantity is large. As to the existence of copper in this district in paying quantities, I do not know enough to speak at present. We have the most beautiful amethysts in large quantities, and agates of a superior quality are found about the shore. At present, as far as known, the most extensively diffused minerals in this district are iron and silver. As far as we know at present the iron deposits are very large, and at Antler river of very good quality. In the Mattawa district I understand there are large lodes of very superior quality of iron ore. Iron ore also occurs on the Kaministiqua, near the railway crossing. It is reported, and I think ascertained for a fact, that the great Minnesota iron range extends past Gunflint lake. It is also reported that large deposits of iron ore have been found at Hunter's island. I believe that range of iron extends clear through our country, and that the iron deposits of the Mattawa are really a continuation of it. I believe the deposits of iron to be inexhaustible.

Minerals and building stones of the Lake Superior district.

Peter McKellar—I came here in 1863 and have spent most of my time since then in this district. I have been engaged in exploring for minerals, and have done so to a great extent during the time I have been here. I have prospected all along the shores of lake Superior, from Michipicoten to the

An extensive mineral bearing region.

American boundary, and back as far as the height-of-land. I have been to Lake-of-the-Woods, lake Nipigon, the Whitefish—all over in fact. I have a knowledge of a large extent of country. Gold, silver, copper, lead, zinc and iron exist in such quantities that they will ultimately pay, though some of them may not do so at the present time. There are also telurium, bismuth and molybdenite, besides a great number of other economic minerals. Stone of different kinds and marbles are found. There is a great variety of crystalline rocks, such as granite and syenite, in large quantities. At Black bay there is an immense quantity of granite that takes a beautiful polish. It is finer grain than the Aberdeen granite, and is in great bodies. There is a fine red sandstone in Nipigon bay. These quarries of sandstone, granite, etc., are handy for shipping, as wharves may be built right alongside them. There is a white sandstone in large quantities at the foot of Thunder bay that is of the finest quality. There is also a bed of marble and a very good quality of soapstone. It turns, further back, into marble of different colors, some banded, some clouded, and all very easy to quarry. It is in the Nipigon formation. The brown sandstone will prove very lasting, but it is not as hard as the white. In this section we look for silver veins in black clay slates; galena and zincblende especially are a good indication, being generally associated with silver in the vein. At McKellar island the blende will go from $800 to $900 of silver. I notice, as a general thing, that the veins are rich beneath the trap overflow. They usually run up through the trap, but are not so rich in it; they carry silver, but not much. The bed below the trap seems to be the richest. Bonanzas are often found immediately below the trap, in the first layer. It is hard to say whether it is the trap overflow or the underlying Huronian beds that cause the richness. The gold-bearing rock occurs in the Huronian schists, the chloritic schists. In many different places in this formation gold has been discovered. At Heron bay a vein shows well. At Jackfish bay they have got gold, but one cannot tell without a regular mining test whether it will pay. We sank on one vein twelve feet; it was rich in gold all the way down. We had half a ton of the ore from Jackfish bay put through a mill, and it concentrated as high as $1,000 and $1,200 to the ton. The Jackfish vein is in the syenite, and the Heron Bay vein in the Huronian formation.

Marbles, granites and sandstone.

Silver occurrences in trap and slate.

Gold-bearing rocks.

W. W. Russell—We have a north-west and south-east system to which the Beaver and Silver Islet mines belong, and an east and west system to which the Silver Mountain mines belong. The Badger belongs to the same as the Beaver, but the majority are east and west, or a little north of east.

Systems of veins.

J. C. Haskins—I think this Thunder Bay district is one of the finest mining regions in the world, and I have been working at mining since I was twelve years old.

Walpole Roland—I have spent fourteen years continuously exploring in this region. I have been in Nova Scotia, British Columbia, and the Northwest generally, from two and a half to three years in the inland mines of India, and in other parts of the world, and this region, in my opinion, is without a rival. One old mining gentleman that I met from the west said, "If we had such ores and prospects in our country our people would simply lose their heads," and he said he had never seen anything like it. The testimony of Americans generally has been uniformly in the same direction.

An old explorer's opinion of the Lake Superior region.

T. A. Keefer—Gold has been found chiefly in the rocks of Huronian age in the Lake Superior district. The discoveries made in veins in the stratified rocks, especially in the talcose and chloritic schists, are in my judgment those which are most likely to be successfully operated. Development works in the gold-bearing sections of the country have been prosecuted on various properties, but on a very limited scale, the greater development having been made at the Huronian company's mine, in the township of Moss. Adjoining the Huronian mine are the properties of the Highland and Neebish mining companies, on which some work has been done with satisfactory results, as far as prosecuted. I may say the same result followed what little work was done at the Partridge lake gold mine, some miles north of the Huronian. Here the gold was found, as at the Huronian group, in its native state, and with sulphurets in a quartz vein in rocks of Huronian age. A test made of the Partridge lake gold mine ore showed that portions of the gold could be saved by the free milling process, as well as by concentration, by the same methods and kind of machinery as were applied and used successfully at the Huronian company's mine. Silver is found in the Thunder Bay district in its native state in its richest ore, argentite (black silver), as well as in union with zincblende, galena and pyrites,

The Huronian and other gold mining locations.

Silver occurrences in the Thunder Bay district.

the sulphurets usually being richer in silver when found in close proximity to silver either in its native state or in the ore or argentite. The best results obtained from mining work in this district have been from the developments made on veins in the argillites or Animikie series of the Lower Cambrian formation, here more commonly called the black silver-bearing slates of the Thunder Bay district. Some failures have occurred in the past where work was started in this formation in its lower beds, where the cherts and dolomites are so common, and generally along the edge or skirt of the formation where the bed of the slates is thin, and where it has been soon penetrated by mining work. The syenite has not as yet shown itself to be a rock congenial to the production of silver in this district where veins occur in it. If more attention was paid to locality and to the results of these past as well as more recent developments, and if this theory was better understood, I am convinced that better results would follow like the good ones obtained where mining has been carried on in the proper silver-bearing horizon of this formation. Some efforts, where the slates are thick and higher geologically, have not been successful for various reasons. I may mention one. The veins are not rich everywhere, but the middle or upper portions of these Lower Cambrian shales have their rich ore shoots and deposits which when discovered are usually very productive. The Silver Islet mine, on a vein which cuts a large trap dyke at its junction with the dyke and the silver slates in comparatively a higher portion of the slates than where other efforts failed, produced upwards of $3,000,000 of silver. You probably have the records of production from the Rabbit Mountain and Beaver mines, while you know of the very rich ore produced in smaller quantities and the showings visible at other mines in the district, such as the Porcupine, Silver Creek and others which could be mentioned. Since the Commission took evidence here, the Badger mine, which, like the others mentioned, is relatively in a higher geological position than some which have not produced so well, has made a valuable shipment of a very high grade of ore. I am told on reliable authority that a recent shipment of a car load of about fifteen tons of hand-picked high grade ore from this mine returned over $35,000, and that another car load of a similar grade of ore is now ready for shipment. In addition, there is on its dumps, it is claimed, about one thousand tons of mill rock awaiting the starting of its mill before this ore can be turned into money. It is unnecessary to refer to assays or mill tests of the silver mines to prove Rich ores. the richness of their veins when the eye can see the silver in such quantities in its metallic or native state, as well as in its rich ores so readily discernible. I am of opinion that the trap dykes and overflows of the country have materially assisted the mineralisation of the veins, and that the silver-bearing veins are more likely to be rich in the neighborhood of dykes, as at Silver Islet and Rabbit Mountain mines, or in the slates in their higher positions which have had the influence of the trap overflows, as at Beaver, Badger, Porcupine and others. These opinions may afford ground for further investigation by the geological authorities, while experience and results hereafter may establish facts which will be better understood. I believe them worthy of consideration from the experience I have had and observations I have made in the district. To give an idea of the grades of hand-picked Surface pickings from Rabbit Mountain mine. ore from the silver mines in this district, I may state that when opening the Rabbit Mountain mine I shipped 5,580 lb. of ore from the surface pickings which yielded, on being sold to the well known smelters, Messrs. Balbach & Son of Newark, New Jersey, 775 oz. in silver to the ton of 2,000 lb.; and that from a pit sunk on the vein to the depth of ten feet I made a further shipment of a car load of ore which on being sold to the same smelters yielded $640.41, or after deducting smelting charges, $590.40 per ton of 2,000 lb. Copper exists in the district in its native state, in pyrites and as grey copper. The pyrites Copper. sometimes also carries either gold or silver, and sometimes both. The pyrites usually occurs in veins in the Huronian rocks. Nothing but preliminary work has been done to my knowledge on these veins. Besides the vein at the Tip-Top mine, I know of a deposit near Little Pic river the ore of which carries from five to twenty per cent. of copper, and usually gold and silver in varying quantities. Galena exists in the district, but the veins of it have not been developed. Galena. They occur in different places, the most I know of being in the neighborhood of Black bay. Should smelters be established in the district these veins may become remunerative. They usually carry some silver. Zinc has also been discovered in the form of massive zincblende, or "black jack," the most notable Zinc. deposit I know of being that at the Zenith zinc mine, north of Nipigon bay.

LAKE-OF-THE-WOODS REGION.

Lake-of-the-Woods gold.

George Mitchell—I have noticed that in the several shafts sunk in the Lake-of-the-Woods region free gold is found near the surface, fine and coarse, and in the leafy form, the latter especially in the Pine Portage vein. Below the influence of the atmosphere the gold is invariably found with sulphurets. In the Winnipeg Consolidated the richest part of the vein was in the sulphurets. I cannot tell the results of the concentrates, but assays of them were made by Prof. Chapman, of Toronto, and J. B. Berryman, secretary of the company, of Minneapolis.

Iron on Eagle river.

Gold on Seine river.

Dr. Henson—I have seen a deposit of magnetic iron ore about fifty miles north of the Canadian Pacific railway, on Eagle river. There seemed to be a large deposit as seen from the river (a sample of which is produced). I saw specimens of gold taken from a location on Seine river, in the possession of Mr. Pither, Indian agent at Fort Francis, which was quite rich in free gold.

Gold in Lake-of-the-Woods region.

Wm. Murdoch—I have visited Sultana island, Lake-of-the-Woods. There are six different veins I visited, and ten foot holes have been made on them. These specimens are from Hand and McMicken's location, Sultana island. There are two veins within forty feet of each other; the veins are three or four feet wide, and they widen as you go down. Gold seems to be disseminated through all the veins on Sultana island, and I think the indications are very good. I have seen very fine specimens from Hay island, but there is nothing doing on account of the want of capital.

Lake-of-the-Woods region.

Gold-bearing quartz.

Iron ore.

Minerals on Rainy lake.

Discovery of silver.

Mineral paints.

Mica.

Continuation of the Minnesota iron range.

John McQuarrie—I reside at Rat Portage and am engaged in lumbering on Rainy river. I have been six years in that part of the country, and have had plenty of opportunity of exploring it. Although not a mining prospector I have gone over the country a good deal, and made it my business to investigate its resources for general information, and I have a general knowledge of the mineral wealth of that region. There is gold-bearing quartz and silver there; the gold predominates. I have been on some of the mining locations, among them being the Winnipeg Consolidated, Minerva, Gold Hill, Sultana and others on the same leads. I made a personal examination of these locations and discovered gold on three of them. There is iron in that district also, and I have been on one of the locations. It is north of Rat Portage, on the east side of the Winnipeg river, between Lake-of-the-Woods and English river. I examined this property in 1884. The discoverer was a man named Miles, and he believed from what he heard from those who tested the ore that there was a fortune in it for him. The property at first sight appeared to be a solid mound of black rock, and I could hardly believe it was iron. It was about 70 feet in height and about the same in width. We went to the top of it and could observe the ridge for nearly half a mile. The iron lies in a dark rock of the nature of slate. We took half a canoe load to Rat Portage. It is magnetic ore. There are some fine specimens of gold, iron and silver on Rainy lake. Mr. Alex. Baker, of Fort Francis, has some splendid specimens of gold and silver which he claims came from there, and also lignite. They were found on the north shore of Rainy lake. Mr. Thomas Sheppard also had specimens. The quartz was claimed to be gold-bearing, although it does not show free gold, and on analysis there proved to be considerable silver as well. Several specimens have been brought in by Indians, but they want money before they will tell where the deposits are. There is silver about three miles north of Rat Portage, near Lake-of-the Woods and not far from the Canadian Pacific railway. This discovery was made on the 2nd of January last by Mr. Charles Moore, of Port Arthur. There are three locations taken up on the one lead. Mr. McKay, of Calgarry, told me the lead was 40 feet wide. It is the only silver ore I have seen in that country that looked like the ores around Port Arthur. No development work has been done there beyond exploring, testing and getting claims registered. I have seen some yellow ochre brought in by bagfuls from the Lake-of-the-Woods of just as good quality as that sold by the druggists, and also some Venetian red. It could be used upon outside walls without grinding, and would make a splendid mineral paint. There are also large quantities of mica of a very clear quality in the Lake-of-the-Woods district. I have noticed pieces 6 by 8 and 8 by 8 inches quite clear. I saw one vein which has been taken up by Mr. Parsons and Mr. A. Matheson, the Hudson Bay company's factor. The property is about fifty miles from Rat Portage, and the vein is about eight feet wide. It is claimed that the iron on Rainy lake is one of the most valuable mineral deposits in the country. A gentleman named Fraser came there from the Red lake iron range in Minnesota, and he said he discovered a continuation of the range on the Canadian side of Rainy lake; he believed it was as rich or richer than the

deposits on the Minnesota iron range, as it was better ore. There are a large number of explorers in that region, and they are chiefly Americans. It would be no exaggeration to say that there is a belt of land one hundred miles in length and thirty miles in width north of Rainy river and Rainy lake the general character of which is unexcelled for agricultural purposes by any other section of equal area in Canada or the United States. The soil is a rich clay loam, eight, ten and fifteen feet in depth. The country is not rocky, and it is timbered with cedar, tamarac, spruce, poplar and some fine white pine. A number of settlers went in last year. The first settlers went there about twelve years ago, when the Fort Francis lock was built, and there are some farms and clearings giving most encouraging results. I have known 70 bushels of oats and 35 bushels of spring wheat per acre to be grown there. One farmer has raised fall wheat for the last five years and got about 30 bushels to the acre. The fall wheat was sown where barley had been grown the year before, and he simply harrowed the land for the wheat without plowing. Character of the Rainy river country.

Frederick Miller—I am a mining engineer by profession and reside in Toronto. I have explored around the Georgian bay, Port Arthur and Lake-of-the-Woods. I spent two years in Madoc. I was engaged operating a gold mine on lot 10 in the 10th of Marmora, but it did not amount to anything. I have visited many of the mines between Thunder bay and Pigeon river. The Argyle mine on the Clear river has a good showing, and I have seen particles of gold the size of a grain of wheat. There are numerous veins on the Lake-of-the-Woods that are worth developing, and that will be developed as soon as patents are granted. Various regions.

GENERAL SURVEY OF THE PROVINCE.

Dr. Selwyn—I have been director of the Geological Survey of Canada for the last nineteen years—since 1869. I have explored many parts of the country myself, but have not been much over the eastern part of Ontario. My explorations have been mostly in the western part; that is about Lake-of-the-Woods and west to Manitoba; also around the north shore of lake Superior. I have been around the whole of the north shore from Port Arthur to the Sault. I know the silver bearing region west of Port Arthur, the region around Lake-of-the-Woods, and Lake-of-the-Woods itself to some extent. I have travelled through the country between the silver bearing region and Lake-of-the-Woods. I have not been on the height of land between lake Superior and Hudson bay. This summer I was through the district north of the Georgian bay, through Algoma, in the neighborhood of Sudbury, and from there to the Wanapitae and Vermilion rivers. I have not explored closely west of the Vermilion river to the Lake-of-the-Woods. I was at the Garden River and Echo Lake mines, and this summer examined the country from the Sault Ste. Marie to the Bruce Mines. I have not examined the coast east of the Thessalon river, and cannot say that I have explored that river. I have been on parts of the Vermilion and Spanish rivers. I have travelled through the country south of lake Nipissing, but have not explored it. I have travelled in the neighborhood of Owen Sound and Collingwood. I have travelled through Hastings and have visited the gold mines of Madoc and Marmora and some of the iron mines. I have not visited any of the phosphate mines of Ontario. I have not explored any parts of Renfrew. A great portion of the knowledge I have is from the work of my assistants. I cannot remember all the places where gold occurs, but I could indicate them on the map. Wherever the Huronian rocks occur you are likely to find gold bearing veins, and also other mineral deposits. That has been the reason I have made it my object to trace out the Huronian areas and show them on the maps. Some of the iron ores occur in the Laurentian. Gold especially is associated with what we call the Huronian rocks. When we get into the typical Laurentians, where there is no interlamination of Huronian rocks, we find that they are very barren of economic minerals. One of the best proofs of this is that in the great breadth crossed by the Canadian Pacific railway on that formation there is almost an entire absence of mineral veins of any importance. The largest band of the Huronian is the one north of the Georgian bay. It commences near Killarney, strikes north-east and crosses the Canadian Pacific railway as shown on the map. The diorites are almost invariably associated with gold bearing quartz veins. As far as I know the western limit of this Huronian area is on the upper branches of the Vermilion and Spanish rivers. Another area occurs in the valley of the Michipicoten. The exploration of the back country has been principally along the channels of rivers, Regions explored. Tracing out Huronian areas.

and though that gives a general idea of the country it cannot be considered an exhaustive exploration, yet I do not hesitate to say that the publication of the geological map has been of considerable assistance to prospecting in those districts. Between lake Superior on the east and Lake-of-the-Woods on the west several belts of the Huronian occur, running north-east and south-west. In the Lake-of-the-Woods the Huronian occurs very largely developed, and all the recent discoveries of gold in that district are in that formation.

Gold associated with Huronian rocks.

Everywhere I know of in eastern Ontario gold is associated with the Huronian rocks. It occurs in rocks that have been called Laurentian, as at Madoc and Marmora, but that they are so is doubtful; they are more like Huronian rocks. The principal gold finds as far as I know in Lake-of-the-Woods district occur in the Huronian rocks, as does also the Huronian mine further east, and others in the vicinity of Lac des Mille Lacs. The next and perhaps the most important gold district is in the vicinity of Sudbury. They are now finding gold bearing veins down the Thessalon, and all through that region from the north shore of the Georgian bay to north of Sudbury. I have been examining the veins of Lake-of-the-Woods, Sudbury and Thessalon during the last three weeks, and my opinion of them is much the same as I expressed of the Marmora and Madoc gold mines. I considered the veins were not sufficiently large or constant to prove very profitable; that while at times they are very rich, only very exceptionally will they prove to be permanently profitable. With few exceptions, as far as I have seen, they are not what I consider to be real fissure veins; they are gash veins, more or less lenticular. I have come to the conclusion that if you can examine the outcrop of a vein on its strike or horizontal extension you have good evidence of how it will behave on its vertical extension.

Lenticular gash veins.

This lenticular character of many of the veins is characteristic of the Huronian gold veins. The best veins in Australia are in soft slaty rocks, not at all like the Huronian gold rocks. I consider that diorite and most hornblendic rocks are of igneous origin. The vein matter differs, but is mostly quartz; gold has been found in a great variety of rocks, and it has been stated that ~~traces of it~~ can be found in almost every metallic mineral. Near the surface gold is almost always in the metallic state, but as you get down it passes into sulphurets; that change occurs about the line of permanent saturation. I have not seen much mispickel in the Lake-of-the-Woods and Sudbury districts; magnetic pyrites containing nickel and other sulphurets of iron and copper are the prevailing ores. I do not know whether any of the Lake-of-the-Woods ore has been assayed for nickel. I never saw mispickel elsewhere in such quantity as at the Marmora mines.

Auriferous veins.

At Sudbury I did not see any mispickel. In Nova Scotia the richest specimens of free gold were found near the surface. As they got deeper in most cases the veins appeared to get poorer, that is, the yield was less; but it was not so in reality, much of the gold being lost with the pyrites in the tailings. Dr. Hunt made several analyses of Nova Scotia tailings and found nearly as much gold remaining as had been taken out.

Vermilion mine.

I was at the Vermilion mine, but did not examine it to any depth as they would not allow me to go down into the mine. I could not trace the vein far, perhaps 50 or 60 yards, but the rocks are not well exposed; it is a quartzite, alongside of which is a great band of diorite. The mine on the top of the hill seems to be in diorite. The Huronian rocks are generally hard and tough. The softest and best matrix is at the Huronian mine; that vein can be traced several hundred yards, and is I think four or five feet wide. I have not seen very wide veins. I have seen one for a short distance eight or ten feet. There is one opposite the Whitefish station on the Algoma branch of the Canadian Pacific that is very wide and massive, but it seems to be pinching out.

The Sudbury district.

I could not see any mineral in it except a little pyrites, but the owner told me samples had been assayed and gave a considerable yield. All through the Sudbury district there are numerous veins, and any of them may turn out auriferous. I don't think there is any doubt but that there are a great many veins that have not been discovered.

Alluv

There is an immense area that has not been prospected at all. I have never found gold in alluvial soil in Ontario, but I have been told it occurs at Rat Portage, and that wherever these rich veins are you can scrape the soil and wash out gold.

Silver bearing rocks.

I have never seen it washed out as they do it on the Saskatchewan, but I think in some of the valleys there should be alluvial gold. The silver bearing rocks are altogether different and distinct from the gold bearing.

The Animikie series.

They are in the Animikie series. That series extends westward from about the east end of the Nipigon bay. It crosses the Canada boundary on Pigeon river, and I think extends to near Duluth. It occupies several townships

west of Port Arthur. The Kakabeka falls are near its northern boundary. The rocks composing the Animikie series are very fine cherts, argillites—or, as most people call them, slates, but not such as will do for roofing—and dolomites, trap layers and dykes. I have examined a number of the silver veins in that district. They vary in their course I think; if I remember rightly they are a few degrees north of east and south of west. The veins are of different widths—I have seen some very good ones five or six feet wide. They are almost all in the argillites; the only exception that I know of, and it is hardly an exception, is Silver Islet; and of that the productive part occurred in a dyke that cut the argillites. In the neighborhood of the Rabbit and Beaver mines there is a dyke cutting the veins. I understand they struck a dyke in the Beaver. As a rule the silver bearing veins are calcareous. A great deal of the matrix is calcite, and there is only a limited amount of quartz. In the gold veins calcite is almost absent. In the rich bearing gold veins the matrix is quartzose, but there are exceptions. In Nova Scotia there was a vein of pure pink crystalline calcite that gave a good yield of gold. I think very highly of the silver bearing veins; most of them are true fissure veins. The general width of the silver veins varies much, but I would say that three or four feet would be about the average. I am not aware of the occurrence of silver as native silver in any place else in Canada, but it occurs with galena and gold elsewhere. I cannot say whether it occurs with galena in paying quantities. Some assays of samples from tha Garden River mine gave 800 oz. to the ton. I am told that mine is closed on account of litigation; it is in the Huronian formation. The Temiscaming galena gave a considerable amount of silver. If a vein is very large a small amount of silver will make it pay. When it occurs with galena it is not difficult to extract; it has to be smelted of course. I have heard of it in the neighborhood of Allumette island in the Ottawa. There are a number of places where you will get galena that will give an assay of a few ounces of silver to the ton. I am not aware of any place where it has been found in the Laurentian formation. Sir William Logan pointed out two copper bearing series around lake Superior; the lower is the Huronian, and the upper is the Keweenawan, which lies over the silver bearing Animikie, and corresponds as far as I know with the copper bearing rocks in Michigan. The Keweenawan series has been traced out; the rocks of that formation occur in the Nipigon basin, around Nipigon bay, and are found as far east as Gros Cap. Michipicoten island is entirely composed of them. They occur at intervals along the north shore of lake Superior, but they do not appear extensively till you get to St. Ignace, Simpson and other islands which form the southern shores of Nipigon bay. They extend a little way inland on the north shore, but not far, and I do not know that they have been found to be copper bearing there. The greatest exposure and thickness of them occurs on Simpson and St. Ignace islands. At Michipicoten island and at Mamainse point sulphurets as well as native copper were found. I do not know that the sulphurets were found in sufficient quantities to pay; the mining there was for native copper. I saw nothing at Michipicoten that I could call veins; there are beds impregnated with copper not unlike those of the celebrated Calumet and Hecla mines. Similar beds occur at Mamainse, and there are some sulphurets. There is no exposure of copper at Gros Cap that I know of, though the cupriferous amygdaloids occur there. At St. Ignace mines were opened forty years ago and nothing has been done since, but I understand work has been done there lately. At Silver Islet the sinking over 1,000 feet did not reach the bottom of the Animikie series. In the Shuniah mine they penetrated to the granite; I am not certain whether the vein continued in the granite. One of the great mistakes that our miners have made in the past has been injudicious work and expenditure. The reason sometimes given for so doing is that they have to make a show. Nearly all the copper in the Huronian is in quartzose veins in the character of yellow sulphurets; in the other formation native copper predominates. In the province of Quebec there are mines in the Huronian or Pre-Cambrian rocks, and there is another set in which native copper occurs belonging to a higher series and holding the same relation to the Huronian that the Keweenawan does on lake Superior. The Wallace mine is the same as the Sudbury mines; it is a nickeliferous pyrites. The Sudbury ores are in a great impregnated bed, not a true fissure vein, and the ore exists in vast quantities. I cannot say whether the operations there will be successful or not; much of the product of the mine is wasted. If the ores were treated by the Vivians in Swansea they would save the iron and the sulphur as well as the copper and the nickel. They mix ores from all parts of the world, and they can then work them

The silver bearing veins.

True fissure veins.

Silver occurring with galena.

The copper bearing rocks.

The Keweenawan series.

Michipicoten island.

Mamainse.

Gros Cap.

St. Ignace.

Silver islet.

Shuniah.

Quartzose veins.

The Wallace and Sudbury locations.

Copper Cliff mine. The Bruce mines. Nickel. Iron ores. Occurrence of magnetic, hematitic and specular ores. Deposits on the Kaministiquia. North of lake Nipissing. At Goulais bay and Gros Cap. Stobie mine. In lake Nipissing. On the Ottawa river. In Renfrew and Lanark. Carleton Place. On the K. & P. railway. In the Hastings section. Sulphurous ores. Phosphate of lime. The deposits irregular. Mica. Marble. The Garden River band.

to greater advantage. I went to the Copper Cliff a couple of years ago ; it is a great massive impregnated bed or stockwerk. I saw the Bruce mines when in operation in 1873, and was there again this summer. The veins there are more regular ; they appear to cut through the rocks. There may be a true fissure vein without displacement. I have seen gash veins very continuous for a long distance. What I say in reference to veins generally is, that as you descend they will as a rule be about the same as they are on the surface. The ore in the Bruce mines did not give out at all ; the work stopped on account of a fall in the price of copper. I know of no place where nickel is associated with pyrrhotite in paying quantities except at Sudbury. There they are looking entirely to the nickel and not to the copper to pay them. Both hematite and magnetite ores have been found in large quantities, but more magnetite than hematite. In some mines they are mixed, as at the Haycock mine near Ottawa, where we find both together. Specular ore is also found with them to some extent. It is found with magnetite in the eastern townships of Quebec. I have not seen any large quantities from the large magnetic deposits of Ontario. The magnetic ores are generally associated with the Laurentian rocks, and mostly in the vicinity of crystalline limestone. We find both hematite and magnetite sometimes associated with the Huronian rocks. On the Kaministiquia river a jaspery ore occurs ; there is also some hematite. The last place I saw such a deposit is 28 miles east of Port Arthur. The deposits are in the nature of contact deposits, at the junction of two formations. I think the rocks in rear of Port Arthur are a continuation of the Vermilion range of Minnesota, and there is no reason why the deposits should not be as rich on the Canadian as on the American side. As I understand it, iron occurs in both the Huronian and the Animikie formations ; the hematite mostly in the Animikie, and the magnetite mostly in the Huronian. There is iron ore on the north shore of lake Nipigon. I think it is very rich, but as far as I know it has not been analysed. I have seen specimens of it ; it is a slaty hematite. Deposits have been opened up at Goulais bay and at Gros Cap ; those are in the Huronian, I think. I visited Gros Cap and found a pit dug out and some of the ore thrown up ; it was magnetite. I visited the deposit worked some years ago by Mr. Stobie, known as the Stobie iron mine, north of lake Huron. It was opened in two places ; it is associated with Huronian quartzite. I never saw any iron ore in the Sudbury district. On an island in lake Nipissing there is what is considered to be a large deposit. I cannot say whether it is in the Laurentian or not. As a general thing iron ore in the Laurentian rocks is associated with crystalline limestone. I think the Huronian rocks are very favorable for iron ores, but some of them carry a good deal of titanium. I have heard of iron ore up the Ottawa, and it is quite likely there are such deposits. I have not examined Renfrew county or North Lanark, but Mr. Vennor mentions a good many iron deposits in that country. He found magnetite, but I do not recollect whether he found hematite ; I think he did, but am not certain. I do not think he found any bog iron. At Carleton Place there are showings of what appears to be good iron ore ; it seems to lie in a fissure in calciferous limestone. I have not visited the mines along the Kingston & Pembroke railway. I think Mr. Coste visited them recently. I visited Hastings section some years ago, when the Gatling Gold mine was being worked, and I stated my opinion then as I have stated it to-day. There is plenty of iron ore in Ontario, but many of the ores contain a great deal of sulphur. The ore is chiefly magnetite. There are large deposits of iron ore in the Laurentian formation, but I cannot say anything about the quality of any particular deposit. They vary considerably in this respect. I have not examined the phosphate beds in Ontario ; I have in Quebec. They occur on both sides similarly, and in the same rocks on both sides of the river ; and I do not see why there should be more on one side than the other, except there is a larger area of the Laurentian rock on the north or Quebec side. I never saw any deposits that I could say were interstratified ; they are very irregular. I have seen no evidence to lead me to suppose that phosphate bearing beds are shallow. I believe you can follow them down to any depth and be liable to find apatite deposits. I have no personal knowledge of mica in Ontario. The best mica mine now being worked is the Villeneuve mine, in the province of Quebec. At Garden river they are opening a quarry of beautiful dark marble, a Huronian limestone or dolomite. The Garden river band extends for many miles; it crosses Echo lake and has been traced and mapped through that country by Sir William Logan. I do not think it is uniform in character ; in one place I think the beds would be better than in others. It seems to be a very beautiful and good marble, and the openings of

Garden river I consider look exceedingly promising. Wherever the Laurentian limestones occur we can quarry them for marble, but they are generally coarse in the grain. I have not seen the marble at Bridgewater, but suppose it is the ordinary Laurentian crystalline limestone. I have seen some specimens that were brought from the township of Barrie. The marble there is coarse grained, and has specks of quartz and other minerals in it. I have seen the Arnprior marble, and think there should be no difficulty in quarrying it. Some of that marble is very beautiful. It has already been extensively used and its value proved. All limestones capable of taking a polish are marbles. I have never visited the gypsum beds; they were examined and described years ago. Most of my time has been devoted to areas never visited before by the survey. The specimens of gypsum from Ontario show it to be as good as any you can get for making plaster. I do not think it occurs in quantity in Ontario unless it be in the basin of Moose river. I do not know of its being there, but I think it is likely to be found. There is in Ontario an unlimited amount of salt; the quantity that can be obtained is only limited by the demand. I think Dr. Hunt made analyses of it and reported fully on its occurrence. In all probability there is a very large area of petroleum bearing strata under central Ontario which has as yet never been reached, and which corresponds with the Ohio petroleum bearing strata. I think there is no doubt but that the province of Ontario has great mineral resources which are awaiting development. Not one-tenth part of the country has been explored. With a thorough exploration many valuable discoveries should be made, though many of them could not be utilised under existing conditions, such as difficulty of access, etc. When these change they will become valuable, and in the meantime the knowledge of their existence will of course hasten that change.

Laurentian limestones. Barrie. Arnprior. Gypsum. Salt. Petroleum. The importance of exploration.

E. B. Borron—North of the height of land between the great lakes and Hudson bay is a territory containing some 60,000 square miles. I have traversed this territory from the height of land to James' bay on all the principal rivers, and have ascended many of the chief tributaries. The exploration of this territory is rendered very difficult, and for the most part impossible, owing to the fact that the face of the country is almost entirely covered by boulder or drift clays, sands and gravel. In no part of the province is so small a proportion of the underlying or bed rock exposed to view. So much of the rock as can be seen is found on the banks of the rivers and upon the shores of the lakes. In the former it is met with at the rapids and falls, and occasionally near the water's edge, where narrow reefs have been cut through by the action of the water, but very rarely do such exposures extend inland more than a few chains. In the lakes it is generally at the points and headlands where the rock is visible, and also on the banks of the rivers; it is almost invariably concealed by loose material or vegetable growth a very short distance back from the shore. The rocks exposed are usually the hardest and probably the least favorable to the occurrence of metalliferous veins. Before a reliable opinion can be formed as to the value of the mineral resources of this territory a great deal of work must be done and a considerable sum of money expended. Such veins as are already known, if thought worthy, should be traced and uncovered for a considerable distance in order to ascertain their regularity, size and richness. Such deposits as occur in beds must be tested by boring or by sinking pits. This has not been possible in such preliminary explorations as I have been carrying out. So far as I am able to judge those metals and metallic ores commonly found in veins, such as copper, lead, silver and gold, are not likely to be as abundant as we could wish in this territory. I am led to take this view in consequence of the extreme rarity of regular and well defined mineral veins of any kind in the rocks where exposed to view. It remains to be proved whether they are larger and richer in the softer rocks, which are generally concealed. Large trap dykes are often met with, some of which traverse the country for miles, and occasionally powerful granitic and felspathic veins; but good sized metalliferous veins are uncommon. I have no doubt, however, but that in so vast a territory all the metals I have mentioned will be found. I think copper and gold are perhaps the most likely to occur in paying quantities. In reference to those minerals which usually occur in beds or in irregular masses I am able to speak more hopefully. Some of the most valuable of these deposits, sometimes called "flat metals," are found in this territory, and I believe in inexhaustible quantity. Among these I attach special importance to the deposits of iron ore, kaolin, lignite and peat. The iron ores, so far as yet discovered, are chiefly carbonate of iron associated with limestone, and probably containing some lime; rich brown hematite ore, resulting as it would appear from the decom-

The Hudson Bay slope. Difficulty of exploring for mineral veins. Trap dykes and granitic and felspathic veins.

Iron ore, kaolin, lignite, gypsum and peat.

position of the carbonate ; bog iron ores, magnetic iron ore and specular iron ore. The three first exist, doubtless, in very large quantities. The fourth has been found in p'aces near the height of land, probably in considerable quantity. The specular ore has been only found in loose or float pieces. The kaolin is situated on the Missinaibi river, a branch of the Moose, a little below Coal brook. The clay is overlaid by a bed of beautiful white sand. I believe that both the kaolin and the sand, the one suitable for the manufacture of porcelain and the other for window glass, are there in large quantity. The deposits of gypsum are also large. Lignite has been found on the Mattagami and Missinaibi branches of the Moose river, and also on the river Abittibi. It exists in all probability in immense quantity ; but it is impossible to say what the value of the beds may be till they are tested by boring or otherwise. The beds of peat are so extensive as to be absolutely inexhaustible. In regard to the value of peat as a fuel I beg to refer to my report on this territory for 1880, pp. 11 to 21 inclusive.

SECTION II.

NOTES ON MINES, LOCATIONS AND WORKS VISITED BY THE COMMISSION.

The members of the Commission were not able to come together until the 1st of August, owing chiefly to the fact that the secretary was occupied during the whole of the early part of the summer in the work of the Mineral Exhibit at Cincinnati. It therefore was necessary for the Commission to travel rapidly over the province, as otherwise it would not have been possible to visit the mineral-producing districts which stretch from the Ottawa river to Lake-of-the-Woods before the close of the season. This limitation of time made it necessary to restrict the examination of the mines, works and mineral properties visited to little more than cursory glances at each, and it also had the effect of making impossible the collection of a full typical series of specimens from the various localities, or even to properly label and ship those which were collected. The notes of this Section, therefore, have no pretence to fulness; they are intended to record general impressions and observations of places visited by the Commission, and every allowance must be made for their shortcomings as a description of the mines and minerals of the province. Taken together with the voluminous evidence, however, they will suffice to show the great apparent possibilities of the mineral resources of Ontario, which have hardly yet reached the nascent stage of development.

STATISTICS OF PRODUCTION

The table which follows gives the chief mineral productions of Ontario for the year 1888, as far as it has been possible to obtain the figures. A Statistics. process of education seems to be needed before complete returns of production can be hoped for. Time and care are required in the making up of a correct statement of the operations of a quarry or mine for a whole year, as well as a knowledge of the location of every business on the part of the collector of information; and even after the best system has been adopted diligent effort may fail for a time to procure full and accurate statistics of the industry. Every man will not do without some urgency even what he knows ought to be done in this matter; for as a rule the requirements of business are entitled to and must receive the first consideration at the hands of managers, and there is no direct money value in the labor of preparing returns of production for Government use. Every witness questioned on the subject, however, including the capitalist, mine manager, mining engineer, prospector and scientist, gave evidence in favor of the benefit of statistics to the best interests of mining development, and almost without exception they expressed a preference for a system under which the returns of yearly production would be made compulsory under law.

MINERAL PRODUCTION OF ONTARIO IN 1888.

Mineral.	Quantity.	Value.
		$
Arsenious Acid.................tons.	35	1,500.00
Cement.................... bbls.	42,000	30,900.00
Copper Ore.................... lb.	2,860,760	} 286,076.00
Nickel Ore.................... lb.	1,222,040	
Gold	....	2,689.00
Gypsum ....tons.	6,600	13,200.00
Iron Ore .... "	16,000	48,000.00
Mica (partly uncut)............... "	18	30,000.00
Petroleum, crude........bbls. of 35 Imp. gals.	600,000	618,000.00
Phosphate of Lime ....tons.	3,350	44,050.00
Salt.............................. "	56,632	189,974.00
Silver Ore......................... "	130	226,410.00
Building Materials, including building stones, granite and marble, brick, drain pipes, tiles, pottery and lime, estimated value about.....	....	2,000,000.00
		3,490,799.00

Some 4,000 tons of stamp rock was produced at the silver mines and are on hand. It has not been treated and is not estimated, but the returns of 2,550 tons give that quantity a value of $170,000, the stamp rock running from 50 to 113 ounces of silver to the ton. In the two years 1887 and 1888, $413,505 of silver was shipped from Port Arthur. Correct returns under the head of building materials were very difficult to obtain in the time at the disposal of the Commission, and the same may be said of the exact production of petroleum. From the statements received, however, the figures given in the table represent very closely the actual amount produced in each case. Among the items of information received it will be interesting to note in connection with building stone that the Grand Trunk railroad used during the year 17,456 cubic yards in the works of their Ontario system, and the Canadian Pacific railroad 8,900 cubic yards. The Sewer and Drain Pipe company of Hamilton produced seventy-five miles of drain pipes, valued at $200,000; and from returns received it appears that more than 20,000,000 bricks were manufactured in the vicinity of Toronto alone.

ARSENIC.

Arsenic.

A small quantity of arsenious acid is manufactured from refuse mispickel at the Consolidated gold mine in Hastings county, and it is reported to be of the finest quality. This mine will be alluded to later on under Gold.

BUILDING MATERIALS.

Materials used for building and ornamental purposes.

Under this heading comes a great variety of substances in which Ontario is exceptionally rich, viz., ordinary building stones, which abound throughout the whole province; cement rock, worked in several places; clay suitable for brick and tile, obtainable almost everywhere; also clays from which earthenware, terra cotta and sewer pipe are manufactured, and which are

abundant in certain localities. Of granites and marbles there is an unlimited supply, but they vary in different places in structure and color and in freedom from joints and cracks, which conditions determine their suitability for building or ornamental purposes. There is also a so-called actinolite used for making a roofing cement, which, however, is chiefly a mixture of fibrous serpentine and talc. A report on all the building materials of the province would in itself fill a large volume, but only the localities visited by the Commission, or about which evidence has been given, will here be dealt with.

BROWN AND GREY SANDSTONES.

Forks of the Credit.

Owing to the large recent development of freestone of the Medina formation, which assumes a dark brown color in the vicinity of the Forks of the Credit, a visit was paid to the locality by one of the Commissioners. The gap through which the Credit river and the Credit Valley railway find their way from the table-land of Wellington across the county of Peel shows the same formation on its westerly side as is observable at Milton and Limehouse. Fig. 1 shows an average section as represented at the Forks of the Credit. The stone quarried here is sandstone of the Medina formation under Niagara limestone, the dip of which is gently to the south-west.

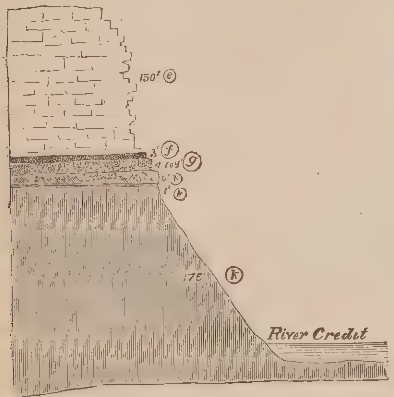


FIG. 1.—Section of escarpment at Forks of the Credit.
e. Limestone. f. Grey sandstone. g. Brown sandstone. h. Bastard formation. k. Blue clay. K. Red clay.

Character of the formation.

Throughout a certain area, of which the Forks of the Credit is said to be the centre, a great body of brown sandstone exists, but the grey band is often mixed with the brown, and in places the colors are blended. It is a most excellent building and ornamental stone, and is coming extensively into use. The chief joints in the formation run a little north of east and south of west. They occur at regular distances, but some are about twenty feet apart. There are also cross-joints, not general or uniform, running north and south. Nodules of clay occur between the faces of some layers of the freestone in a peculiar manner, and a foot of blue clay underlies the bed. Under the blue clay is a deposit of red clay of great thickness, being visible in the river banks to a depth of 175 feet, and it is doubtless the same kind of clay as that which occurs at Milton, which is there used in the manufacture of pressed brick.

Clay deposits.

The quarries at the Forks.

The Chisholm quarry on the north side of the river has been denuded of the overlying limestone, and the layers of sandstone are covered with sand to the depth of 15 or 20 feet. About three feet of the upper layer consists of grey stone, and the brown is in varying thicknesses below the grey. Where there is a deep basin and the layer thickens in shape, the brown stone improves in quality. The total thickness of the formation varies from 12 to 17 feet. Pick and wedge and plug and feather are both used to get the

stone broken up into suitable blocks. Two other quarries are operated on the Chisholm properties, located on both sides of the railway and the river. The other chief quarries at the forks are those of Messrs. Patullo, Yorke and Elliott. The Patullo quarries are two in number, one on the south side of the stream, below the forks, overhanging the railway track, and the other on the north side of the west branch of the river. The quarries of Lionel Yorke and N. M. Elliott are both on the south side of the main stream, overhanging the railway. Besides these, several smaller quarries have been opened at various points along the escarpment towards the south. The extent of the brown freestone will be limited as the work gets under the linestone covering, which overlies it here to a height of 150 feet, but there is practically an unlimited quantity available, although much sorting from the grey is necessary in places. The grey stone is available over a great extent of country along this escarpment, as is also the limestone for rough walls and for the manufacture of lime. The upper limestone is stated to make a better quality of lime than the lower.

Vert island sandstone.

By referring to the evidence it will be seen that in the Port Arthur district valuable building stones abound, especially red sandstone on Vert island in Nipigon bay.

Little Current.

At Little Current, on Manitoulin island, the Trenton formation of the Lower Silurian is visible. A bed of dolomite of six feet in thickness is quarried at the village and makes a very good building stone.

GRANITE AND GRANITE WORKS.

Kingston granite quarry.

The granite quarry at Kingston produces a red quartz syenite with occasional large crystals of pyroxene, but large masses of the granite may be got free from the crystal blemishes. In the joints a little copper pyrites is now and then found. The syenite comes up from beneath the Silurian limestone which ends here just east of the city, and there is an inexhaustible quantity of material to work upon. Small blocks are cut up and sold for pavement for $3.10 per square yard, while the larger blocks are sent to Ottawa to be cut and polished at the works of the Canadian Granite company, which owns the quarry. The shipping facilities are excellent, as boats may be loaded at a deep water inlet on the river side of the property.

Canadian Granite company's works, Ottawa.

The Commission visited the works of the Canadian Granite company at Ottawa for the sawing, turning and polishing of granite and marble. This company controls quarries of granite at Kingston and marble at Renfrew. It is also experimenting on serpentines which come from the township of Templeton on the Quebec side of the Ottawa river, some of which are very beautiful. Serpentine also occurs on the Ontario side of the Ottawa, but at points too far distant to compete in price with the Quebec article. The plant of the works consists of sawing apparatus, rubbing beds, turning lathes and polishing jennies run by an engine of 60-horse-power. Both the granite and marble take an extremely handsome polish and are said to be exceptionally durable. The granite or syenite is said to be harder than the average, and to cost 15 or 20 per cent. more for working on this account.

MARBLE AND MARBLE QUARRIES.

Madoc marble quarries.

In the village of Madoc a band of crystalline limestone of the Laurentian series has been opened to a limited extent for the production of a dark colored marble. The band is about 900 feet across, with a north and south course where opened, lying between granite on the east side and limestone on the west, beyond which latter again there occurs a band of slate or argillaceous shale. It is nearly vertical in position, pitching about 10° to the west. The marble is a fair quality, crystalline and dark colored, polishing almost black. Checks or joints occur here and there near the surface, but are said to become less frequent as the band is sunk upon. The quarry was nearly filled with water at the time of the Commissioners' visit, so that a proper examination of it could not be made, but we were informed that a depth of 38 feet had been attained, and that at that depth the open floors were six to eight feet apart. There are various colored bands, chiefly grey (which, as above mentioned, polish almost black), grey and white mixed, and in other places some white in broader bands with the grey, which could be sawn out. This marble should be well adapted for all mourning purposes, as well as for designs where a dark colored material is required. Its specific gravity is 2.782. The machinery on the ground consists of a 35-horse-power portable boiler, two steam pumps, an Ingersoll gadder, a diamond drill, a channel machine, a 30-ton derrick and necessary tools. Cutting is made with the drill, successive borings on the same line making a clean cut of any sized block that may be required.

Bridgewater marble quarry.

The Bridgewater marble quarry is in the township of Hungerford, in Hastings county, and is worked by the company owning the Madoc quarry. The strike of the band is north and south, dipping slightly eastward from the vertical. On the east is a quartzose rock with large masses of quartz and felspar, immediately followed by a closed grained pink colored syenite. On the west side is a highly altered shale dipping at a high angle. The latter varies in places from a gneissic to a chloritic, talcose and micaceous schist, succeeded by gneiss. This band of marble is some 500 feet wide, and curves around from north and south to south 30° east. Where an opening has been made it is observed that the joints are at right-angles to the strike and running with the dip, and are four to forty or fifty feet apart. The open floors are two feet to ten and twelve feet apart. The seams vary from six inches to ten or twelve feet apart, the average being about two feet. The marble has a pure white color, clouded bluish and greenish in places and with bands of pinkish or salmon color in other parts. These latter bands may be sawn out, being twelve to eighteen inches wide. The marble is closely crystalline, but compact, and is shown at Bridgewater to stand the weather well. A church has been built of it at that village, as well as portions of houses and stores, and they have

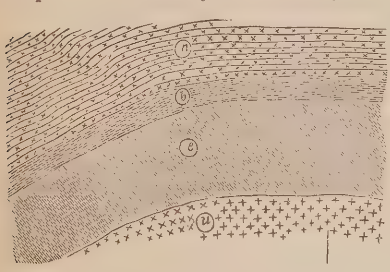


FIG. 2.—Scootamatta marble band.
n. Gneiss. b. Schist. e. Marble. u. Syenite.

stood over twenty years without showing any signs of weathering. It is said to be practically identical with the marble at Gouverneur, in the state of New York. The company expect to be able to ship large blocks, which pay best. The finest quality sells at $2 and the poorest at 50c. per cubic foot. The specific gravity is 2.751.

Renfrew marble quarry.

The town of Renfrew is situated over a very wide band of crystalline limestone, which crops out at different points, but especially upon a lot in rear of the Roman Catholic church. This latter is well adapted for quarrying into large pieces of solid and massive stone, which is free from checks and dries, and stands working, sawing and trimming for marble purposes. The property is operated by the Canadian Granite company of Ottawa, and the product is shipped to that city for manufacture. The marble is a crystalline limestone of greyish hue, slightly tinted in places with hornblendic crystals, and in other places small crystals of mica are visible. It is taken out by block and feather, and costs $2.25 per cord for labor. The largest blocks are nine feet long by two feet square, and about 25 per cent. is wasted in the quarrying. It stands the weather better than any stone except granite, and some granites will not stand as well. We saw one building which had been put up nearly forty years ago. No action from the weather was visible except that the tint had become slightly darker where most exposed, and this change could only be seen upon careful observation.

Arnprior marble quarry.

There is another wide band of crystalline limestone at Arnprior upon which several openings have been made, and near which works have been erected for cutting and polishing. At the works the strata dip 30° to the south-west, and the strike is north-east and south-west. This band is of a bluish tint, with dark blue wavy lines, and yields marble of excellent appearance and quality. The plant of the mill consists of three sawing gangs, three turning and two polishing lathes and a rubbing bed, all driven by a 25-horse power engine. The marble is made chiefly into monuments, but is also manufactured to a small extent into table tops and mantel-pieces, and is used in public buildings for decoration.

Garden River and Echo Lake marble.

Half-way down Echo lake, on the north side, a point of banded marble runs out. It is composed in places of alternate thin bands of pure white and colored stone, much twisted. The colored portions being harder are weathered out more prominently, and show the structure very plainly. Sir William Logan describes its appearance very fully in his report on this district. As a rule the marble is tinted. This is especially the case behind Garden River, where the same series of marbles are again tapped; but at Echo lake there is an immense quantity of the banded marble with pure white streaks. Where again accessible in the bluff about two miles north of Garden River village, on St. Mary river, the band is about a mile wide. The strike is about east and west and the dip about 50° north. The marble is quarried at this location by a Chicago company, and a railroad is being constructed into it from the river. It is a very close-grained and hard stone, and is said to take an excellent polish. The colors are shades of green and pink in different parts of the bed, blending by very soft gradations into white. It is quarried against the north and south joints, and may be got out in very large layers.

CEMENT CLAY AND WORKS.

The mill at Thorold which manufactures the well-known Thorold cement was not visited; neither were the works at Limehouse in the county of Halton, on the line of the Grand Trunk railway; nor at Keppel, in the county of Grey. No evidence was offered respecting any of these. They are all in the Niagara formation, forming one of its lowest beds. Neither was evidence forthcoming in regard to the cement rock in the Eurypterus beds which crop out near Cayuga, and from which formation most of the celebrated Buffalo cement is manufactured. The Commission, however, visited the cement quarry at Napanee and the mills in connection therewith, the property of the Rathbun company of Deseronto. The rock here seems to belong to the Trenton formation, and is worked as an open quarry very cheaply. Fig. 3 represents a section of the formation and quarry. The kilns for burning the rock have chambers 26 feet by 8 feet, each having a capacity of 90 barrels per day. They are drawn every eight hours. The cement mill in connection with the quarry has a capacity of 400 barrels per day, which may be enlarged to 600 barrels. It has now three run of four-feet mill stones, each of which grinds 130 barrels per day. The burnt cement is brought from the kilns by a self-dumping car and emptied into an inclined plane which shakes the charge gradually into a cracker or coffee mill, and thence it runs through the millstones. After being ground the cement is bolted through a screen of 45-mesh to the inch. The cement is said to be slow or medium setting, and tests of strain given by the manager are as follows:

Cement.

Napanee cement.

Cement mill.

24 hours,	25 to 30 ℔ to square inch.
7 days,	50 ℔ to square inch.
30 days,	125 to 140 ℔ to square inch.
60 days,	180 to 220 ℔ to square inch.

CLAYS, BRICK AND TERRA COTTA.

The clays obtained by the Rathbun company at Napanee for their large works at Deseronto, referred to in Mr. Rathbun's evidence, are used to make terra cotta, red and white brick and tiles. It is also claimed that a species of fire clay is obtained from the same deposits. The beds lie just below the cement formation on the flats, and alongside the railway, and are an alluvial deposit. The formation dips very slightly to the north, being almost horizontal.

Napanee mills clays.

The Commission also visited the large new porous terra cotta and brick works of the Rathbun company at Deseronto, which are described in the evidence. The clay is mixed with sawdust, the latter being entirely consumed in the burning. The process is very satisfactory, the product being light, yet strong, and with all the advantages of porosity. It is made into various forms, according to the use for which it is intended. The brick for lining the inside walls of buildings is about 8 inches wide, 12 long and 2 in thickness, and is deeply grooved on one side so as to form a series of upright ventilating shafts when placed in the wall. It would appear to be well suited for economy in the heating of dwelling-houses, churches and public buildings, as well as for purposes of sanitation, and the superior acoustic properties of public halls in which it has been used are said to be very noticeable. The brick used for deafening and fire-proofing is made into sets, each of which

Terra cotta works.

makes a complete arch between the beams or joists of a floor, and is getting in demand for banks and public buildings.

Mr. Hynes of Toronto makes excellent terra cotta ornaments and building material from a clay obtained in Peel county, about which his evidence gives information.

Toronto Pressed Brick and Terra Cotta company.

Near Milton, as at the Forks of the Credit, a thick bed of red clay underlies the freestone at the base of the escarpment. Fig. 3 shows its position at Milton. The works for the manufacture of pressed brick are situated on a switch of the Credit Valley railway and beside a bank of the clay, which is excavated by an open cut, and the material is run directly into the works at a very low cost. In this bed there are occasional layers of greenish clay, which are carefully sorted out when the finest quality of brick or terra cotta is required. The greenish layers are not numerous, and the sorting is not attended with difficulty, although it requires careful attention. Fig. 4 shows a section of the excavation close to the mill. The clay is very hard and is excavated by pick, and also by the use of dynamite. In the latter case a hole is bored with an auger to a depth of three or four feet and the charge inserted. The clay is then wheeled in barrows to the crusher, a dry grinding pan with a capacity of 40,000 bricks per day. After being crushed it is elevated and run through a 3-16th mesh screen ; thence it is run into a large sized hopper and falls into a pressing machine. The press in use is the Victoria dry press machine, patented by Smith Bros. of Galt, and manufactured by Goldie & McCulloch of that town. Each machine, of which there are two in operation here, has four moulds, and can turn out from 20,000 to 24,000 pressed bricks in ten hours. As the clay is pressed dry it may be carried to the kilns at once. Four kilns have been erected, each 20 x 32 feet inside and 12 feet 6 inches high from the top of the fire-places, which are 2 feet 6 inches from the floor. Each kiln has a holding capacity of 120,000 bricks, uses from three to four tons of coal per day and requires eight days firing to finish a charge. It is estimated that 70 per cent. of the product will make marketable brick of good color for housework, the balance being used for inside walls and sewers. The inferior bricks are chiefly from the lower part of the kiln, and though harder they are not so evenly colored as the upper layers. A few bricks are vitrified by the intense heat. The brick is of a rich dark color, and is very hard and compact.

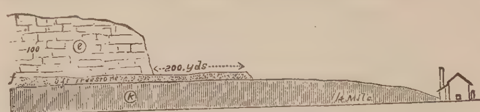


FIG. 3.—Section of formation at Milton brickyard. *e. Limestone. f. Freestone. k. Red clay.*

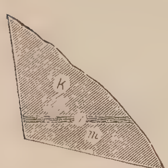


FIG. 4.—*k. Red clay. l. Greenish layer of clay. m. Dark red clay.*

Clay-bed at Hamilton.

The bed of clay underneath the mountain, at the rear of Dr. Springer's residence in Hamilton, was visited by the Commission in December. A surface excavation had been made, but being partly filled with water it could not be properly examined. There appears, however, to be a large deposit of clay of a very fine grained texture and of brown color. A burnt specimen shown us was very hard, and of dark red color.

ROOFING MATERIALS.

Fibrous serpentine, called "actinolite," is found near Bridgewater, in the county of Hastings. No member of the Commission visited the places of production, but the process of manufacture at the mill in Bridgewater was witnessed. This consists simply in breaking the rock in a Blake crusher and then grinding the crushed material in Taylor's disintegrator, after which it is bagged and shipped. The rock is similar to what is called fibrous talc in New York state, where it is ground for a like purpose. Fibrous serpentine.

A fissile shale has been opened upon in the north-west corner of lot 5, con. 6, in the township of Madoc; the strike is nearly 60° east and the dip 80° to the south. It is a very strong shale, and in places cleaves nearly as thin as ordinary slate; color, grey. It has been opened to a depth of 35 or 40 feet. Slate.

Dr. Alexander Pattullo—I reside in Toronto, but am interested in property at the Forks of the Credit, on which there are several quarries. The property is just alongside the mountain and near the railway. The stone is a red and a grey freestone. We supplied a good deal of stone in Hamilton, and I think some to the government buildings there. During the last eight years we have supplied a great deal of stone to people in the city of Toronto, and it has been used in many buildings here, amongst others in MacMaster Hall. We began to work our quarries in 1881, and we are now supplying some of the stone for the Parliament buildings. On the east half of lot 7, in the 3rd concession of Caledon, is the Elliot quarry, containing both grey and red sandstone. On 9 in the same concession we have 200 acres containing red and grey. Mr. Yorke has part of 9 on the same concession, on the east side. Mr. Chisholm has 10 and 11 in the 4th. On lot 12 there is excellent grey stone. That appears to be the northern limit of the freestone region. The grey and red occur in the same bed, in seams. There is no difference in the quality of the stone except that the grey has no coloring matter. The quantity is practically without limit, but there is a limit to the profitable development, as in other parts of the country it is covered by an enormous depth of limestone. The entire length of the outcrops following the sinuosities of the mountain is about 8½ miles. The average depth of the quarry is about 17 feet. There are three persons in our company, and I suppose we have about $20,000 invested. We have sometimes had as many as 60 or 70 men on our pay roll. Wages of quarrymen range from $1.50 to $2 a day. We never had more than one team, so we do not require to use teamsters at all. Our laboring men get from $1.25 to $1.45 a day. I suppose that about $25,000 worth of stone from our quarries has been sold this year. We have very large deposits of deep red clay at our sandstone quarries, at the Forks of the Credit. It appears to be very pure and free from lime; it crops out on the escarpment and could be easily worked. I cannot tell you the depth of that clay exactly. We have 100 feet of the Niagara limestone, then 15 or 20 feet of water lime, and below that layers of clay and sandstone mixed, I suppose for about 100 feet, than a sort of yellow clay, then the freestone, then about a foot of blue clay, and then we come to the red clay; it extends 60 feet above the railway and continues under I don't know how far. It breaks into cubes about half an inch in diameter when dried. It has not been tested by burning. We have also the same kind of clays they use for making fire-proof paints at Limehouse. Forks of the Credit sandstone. Red clay at the Forks of the Credit.

Thomas Marks—At Verte island there is a quarry that has been worked for three years. Large shipments have been made to Chicago, and it is considered by the best architects to be the finest stone in the market; it is better than the best brown stone used in New York. Some of the finest buildings in Chicago are erected with that stone. It quarries out in large blocks of five and six tons. I was told in Chicago that it stands as great pressure as granite, or even more, and they say it cannot be excelled for withstanding frost and fire. The only places where I have seen that stone are on Verte island and Grange island; it is convenient for shipping to all the great cities of the States situated on the lakes. There are 11,000 acres on Grange island; on Verte island the quarrymen have gone below the water line, and there appears to be any amount of it. The formation extends about 100 to 150 feet above the water, and seems to run that thickness across the islands. Verte island and Grange island sandstone.

Potsdam sandstone.

W. J. Morris—There is a fine potsdam sandstone fit for building purposes in the township of Bastard, county of Leeds, which in some places is colored with yellow ochre. It is also found in the township of Elmsley. In Miller, Clarendon, Barrie and Palmerston, in Frontenac, there is marble as good as anything in Vermont—pure white, dove color and pink. The trouble is that it is too far from a railway, about 17 miles. Barrie is the marble township of Canada. Sir William Logan showed me specimens he got there which he said were equal to the best Italian statuary marble. The country has never been properly examined; the six northern townships of Frontenac are a terra incognita.

Marble in the north of Frontenac.

Madoc and Hungerford marble quarries.

A. A. McDonald—I am interested in four quarries, two in North Hastings, one in Hungerford and one in the township of Madoc. We obtain from all the quarries valuable stone for building and other purposes. The quarry in the township of Madoc is commonly known as the Victoria or McKinnon. It extends over 40 acres and contains excellent building stone from 3 to 14 inches in thickness, and in some parts of the quarry in layers of two feet in thickness. The stone is easy to take out, is hard and firm, and partakes somewhat of the nature of a lithographic stone; part of it might be used for that purpose. The property is quite convenient to the North Hastings railway, and some 300 or 400 carloads were shipped this year, part being used for the foundation of the new Parliament buildings at Toronto. It has also been used in many of the principal buildings of that city and has given satisfaction. The Hungerford quarry is on lot 10, in the 9th concession and quite near to the Crookston station of the North Hastings railway. The quarry was opened last summer. The stone is a firm and fine grained limestone, and occurs in layers from 16 inches to 4 feet in thickness. It is well adapted for heavy buildings, railway bridges, etc. Messrs. Manning and McDonald, the contractors, are getting the stone from this quarry for the bridges across the Don. Our object in getting so many quarries was to be in a position to fill any order. There are at present about 40 men employed, and it is the intention to double that number if the demand will justify it. The Crookston quarry is equipped with machinery for the loading of heavy blocks on the cars. The machinery for the other quarries will be in position in a short time.

Hungerford Marble company.

E. J. Whitney—My residence and home is at Gouverneur, in the state of New York. I am acting here as superintendent of the Hungerford Marble company's quarries. The capital of the company is $100,000. The marble at Gouverneur is very similar to the marble here, as is also the country rock, which is principally granite, gneiss and crystalline limestone. That marble sells well, in fact the demand is greater than the supply. The St. Lawrence Marble company have to run night and day to fill orders, and then cannot keep up. These crystalline marbles will stand the weather better than the metamorphic marbles of Vermont, and generally they work as easily. The quarries at Rutland, Vt., have dark stocks and they always have orders in excess of their output, the dark being in great demand for outside work. The St. Lawrence company's marbles stand the weather better, polish as well and look as well. The Gouverneur quarries produce a blue stock that cannot be produced in the Rutland. There are a great many bands of that kind of marble here, and speaking generally all through the country there is any quantity of marble; all that is required is to go down far enough to where it is sound. Under similar circumstances on the other side of the line marble of satisfactory character is produced, and I am satisfied that as good can be found here, and that there is an enormous quantity of it; in fact I think there is no limit to the quantity. Very little of the Rutland marbles is used for outside work on buildings; it is not good for that purpose. The marbles here are good for either inside or outside work. Almost all colors are found, white, salmon, grey, black, mottled, drab, with black veins, with white veins, verde-antique and dove blue. All through St. Lawrence county, in New York, there are gravestones of crystalline marble that have been up 70 years, and they are perfect yet though they were cut out of the surface rock. It will stand next best to granite, but will not moss like granite, and will stand fire better than any other stone. The old Fowler mansion, at Gouverneur, was built over 50 years ago out of just such stone; in 1874 it was burned down, and in 1875 some of the stone was taken to build an hotel. The only effect the fire had upon the stone was where it had gone out through the windows; there it crumbled the corners a little. In the academy at Gouverneur there is a slab that has been up since 1839, and it is as clean as when new. I had a marble shop burned down; the Italian marble all broke into little pieces, the granite also cracked to pieces, while the corners of the crystalline limestone just crumbled. There is no doubt that it makes the best building stone. Wherever

Hastings, New York and Vermont marbles compared.

marble takes a turn or bend it is never sound, but where it straightens out again it is good. I think the black marble here will turn out to be good, it is only a question of depth; in the Rutland quarries they did not get any that was good till they got to a depth of 100 feet. Good black marble is scarce, and if it is first class it is worth as much as statuary; but as a general thing we cannot rely upon getting any quantity of it without being clouded. The demand is limited; the present price of a good fair article is $6 or $7 a foot sawed. The company has opened up two properties or quarries, one of them in the village of Madoc and the other about a mile and a half south of Bridgewater, on the Scootamatta river. The Madoc quarry was opened in the latter part of August, 1887. The band is about 900 feet wide from east to west; it curves, and I have traced it as far as Hog lake, a distance of about two miles from north to south. The lower wall on the east is granite; it dips about 10 degrees to the west. The upper wall is a mixture of granite and lime rock, but not what can be called a conglomerate. The dip is 10 degrees to the west. Beyond to the west is a slate which in some places is tipped up 30 or 40 degrees; in other places it is nearly horizontal. It would be good for roofing, but that it splits a little too thick. At present we have sunk on the Madoc property to the depth of 38 feet, but it is our intention to drill down 300 feet in order to get marble that will do for polishing. The marble is very good, the color a grey black. Its hardness is greater than that of the Vermont white marble, and about equal to the Italian marble. We find that the quality gets a good deal better as we go down. We have not as yet taken out any merchantable marble from that quarry, though we have taken out blocks part of which would be merchantable.* Black marble.

At the quarry we have a 30-ton derrick, a diamond drill, a channelling machine, an Ingersoll gadder, a 35-horse power boiler, two steam pumps, and all the tools required; we have a full set of quarrying machinery. To run our machinery would take from eight to ten men, including one machine runner and two foremen; the rest would be quarrymen. The average wages here is $2.75 for machine runner and $1.25 for quarrymen per day of ten hours; the wages are about the same as in New York state. Besides the Madoc quarry this company is working a white marble quarry near Bridgewater. The location there is about 40 acres in extent. The band is about 500 feet wide, and the course is about north-west and south-east. I have seen where it crops out a couple of miles above Bridgewater, but not below. It crops out at the surface, where work has been carried on. There are several small ridges, each of which shows white marble. The lower wall is granite; the upper wall is gneiss, and is very clearly defined. The marble is white, but has some cloudings of blue and green. The pitch is about ten degrees from the perpendicular to the west. There are two thin layers of salmon colored stone, one about 10 inches and the other 18 inches. At the village of Bridgewater there is similar marble, and it was quarried twenty-five years ago to build a church and some private buildings. We worked our quarry there this summer, removed most of the surface material, and got down about 12 or 14 feet; the work was all done by hand. The quality of the marble is very good and improves as we go down. A large amount of the surface stone taken out would only answer for building, but good merchantable marble is now exposed. We employed ten men there till about the 1st of August. We intend to test the property with a diamond drill. There is no property that I know of that could be so cheaply quarried as this one. It could be worked a good deal cheaper than the Madoc quarry. The marble would be suitable for monumental work; the low grade would make good trimmings for buildings, and the higher for monumental and interior purposes. The price at the mill would be $2 a cubic foot for the better, and down to 50 cents a foot for the poorer qualities. The shipping facilities are not good; we can only ship by hauling a distance of three and a half miles to Tweed. In a direct line we are a mile and a half from

Machinery and wages.

Bridgewater quarry.

* The following report on a sample of marble from the Madoc quarry has been made by Edward J. Chapman, Professor of Mineralogy at Toronto University: "This marble is a dark grey limestone of uniform crystalline texture, and as a rule of good strength. Its absorption is very low, averaging only 0.17 per cent. The stone is thus well fitted to withstand the action of frost, and to resist the disintegrating effects of atmospheric action generally. Its specific gravity equals 2.744. A cubic foot thus averages 171 lbs. in weight. As regards composition, the marble consists essentially of calcium carbonate (commonly called carbonate of lime) holding a little magnesia, with traces only of ferruginous matter, and under 2 per cent. of intermixed silicates. The practical absence of iron ensures the stone against change of color on exposure to the weather; and as the amount of intermixed silicious matter is exceedingly low, the polished surface is not likely to become pitted or otherwise impaired. The stone therefore from this quarry, judged by the sample submitted to me for examination, is a dark crystalline marble of very good quality."

the railway. We were talking of putting up a marble mill and running it by water power, and we could get a head of water of 8 feet, but that has not been decided on as yet. The company has bought 50 acres from the Canada company, and 10 acres from Mr. Clapp, a mile and a half east of Bridgewater, on which there is a blue marble similar to that of Rutland. There is a good band of it from 50 to 100 feet wide; it is distinct from the other. On the Canada company lot there is a large band of serpentine marble. I have examined it once, but have not done anything to it. In serpentine, as a rule, there is a great deal of unsoundness, but this is fair; there is some white in it, and that makes it sounder. There are very few serpentine bands that I have seen as sound as this one. I do not know the width of the band, but judging from the outcroppings I think it is from 300 to 600 feet wide.

Serpentine marble.

J. E. Harrison—The white marble at Bridgewater is exceeding close-grained, rendering it very suitable for fine work, bearing sharp edges and undercutting. For building purposes it has few equals amongst the various kinds of stone now used, being capable of sustaining any pressure required for masonry, and being non-absorbent it is free from discoloration when exposed to the weather. This point of excellence is proved in the walls of buildings, erected from thirty to thirty-five years ago, which show no sign of becoming weathered. It has been used for over thirty years for making lime, and the lime business alone could be made very large and profitable, as has been proved by the experience of those engaged in it heretofore, notably that of the Dudswell Marble and Lime Co. of Sherbrooke, in the province of Quebec. This firm ship, besides marble stone, an immense quantity of lime throughout the province of Quebec and New England, reported by them to have been about 120 car loads per month for 1887. This lime, used for plastering, with clean sharp sand, is glossier, harder and whiter than a finish made of the best plaster of Paris.

The Bridgewater marble.

Its use in the manufactnre of lime.

A. R. McDonald—I live at Arnprior, and am a member of the firm of R. McDonald & Son. I am engaged in the marble manufacturing and producing business. One of our quarries is at the corner of Russell and Elgin streets in this town; the other is about a mile and a quarter distant, in an easterly direction, on a cove of the Ottawa river. The marble from that quarry is known as Ottawa Valley marble, while the other is known as Arnprior marble. We have another quarry here at the mill, but it is the same as the Arnprior. We have three sawing gangs, five lathes, three turning lathes, two polishing lathes, a rubbing bed, and a 25 h.p. boiler and engine. I do not know the total value of the plant. This mill was formerly on the south side of the Madawaska, and was owned by Farquharson, McLaughlin & Hartney; they ran it for about four years. We acquired the property in the fall of 1878 and have been running it since. I cannot tell you what our output is. Our market is altogether in Ontario. It is used for monumental purposes, and to a small extent for ornamental purposes such as table tops and mantel pieces. It has been used for a number of public buildings, among others in the House of Commons at Ottawa. I suppose we make about $4,000 or $5,000 worth of monumental marble a year. The Arnprior marble has a dark blue ground with wavy veins; the Ottawa Valley marble has a grey ground with dark wavy veins. I do not know any other marble that will take as good a polish; it cannot be stained; it will not absorb moisture at all, and it stands exposure well. We have not been working this year, one reason being on account of the state of the market. When we are working we employ from 15 to 25 men. The engineer gets $1.50 a day, quarrymen $1.25, polishers $1.25 to $1.50, stone cutters $1.25 to $2.50, and other men $1.20 to $1.25. One of the reasons that we find it difficult to compete with the American marble is that our stock is very hard and difficult to get out, and then it does not come out in the right shape. American mountain blue is a cheap marble. Southern Falls is a good marble; it is light in color, and I think is as good as this; besides, it can be worked cheaper than ours. The Ottawa Granite Co. get marble at Renfrew, but they don't sell much of it as monumental marble; it is mostly the American that is sold for that purpose. The duty on marble is 35 per cent. sawed on four sides, 25 per cent. on two sides, and in the rough 15 per cent. I am informed that the Americans sell marble here at $2.00 and $2.50, while they sell at $3.50 in their own country. They make a slaughter market of ours, and it is mostly inferior marble they sell here. That is the reason we are not running now. The marble dips about 30 degrees, and runs north-east and south-west. About a mile and a half from here we have a marble very like the Gouverneur marble; it is light grey with light brown streaks and extends about

Arnprior marble quarries and works.

Character of the marble.

American competition.

Extent of the marble bands.

five miles to the south and three miles to the west. There is no granite in this part of the country; it is all marble. North-west it extends about twenty miles, and east of here about 12 or 15 miles. In different places it varies in color and texture.

W. H. Wylie—On the lot adjoining my iron pyrites property in Darling, serpentine shows out of the face of the hill in a large mass. I don't know the width of it; the main outcrop is at least 12 feet. White marble occurs in the same locality, on the lot adjoining the iron pyrites; it shows upon the face of the hill. There are several parallel ledges, and one from which I took a specimen showed about 50 feet long, but I cannot say what the width was. I have not sent specimens to any dealers. It is a long way from a railway, perhaps ten or more miles.

Serpentine and marble in Darling.

J. B. Campbell—There is a great deal of very good marble through the Haliburton country, of the ordinary white crystalline variety. It is both in Snowdon and Glamorgan, and some variegated has been obtained from 17 in the 1st concession of the latter township. Some has been polished that came from Galway, and some taken from lot 32 in the 5th of Snowdon has been used for monumental purposes.

Marble in Haliburton.

Moses Snow—My home is at Bangor, Maine. I am superintendent of the Warmington Stone and Marble company of Chicago. The stock of the company is $100,000. The marble properties of the company in Ontario are near the St. Mary river. There are two locations on Echo lake, but I do not know their number; they formed part of the Indian reserve. Besides the locations on the lake we have another near Garden river; all three were on the reserve. The nearest point is two miles from the river St. Mary. The property consists of a mountain the base of which is about 5,000 feet through, 600 feet high, and 7,000 or 8,000 feet long. Our three locations are about 560 acres altogether. We began operations here about six weeks ago. During that time we have been engaged building a boarding house, blacksmith shop, a stable and a railway. At present we employ twenty-three men; we have not done any quarrying yet beyond taking out a few samples. Our market will be in Chicago; we will ship as building stone, the duty on manufactured stone being 55 cents a cubic foot. In the spring we will put in five crews of 25 men each, and will open the quarry here. We will dredge Echo river to get at the Echo Lake quarry; it is all the same band. I think in the land we have taken up we control all the valuable marble there is in this band. I consider the marble of a very fine quality, the best I have ever seen and I have been in the marble business for over twenty years. We will work it as variegated; we do not expect to get any pure white marble; it is for building purposes we intend to use it. The sizes we quarry are 2 feet by 4, 2 by 6 and by 8. The marble is very free from cleavages, and there is any amount of it.

The Garden River marble quarry.

Alexander McLean—I live in Ottawa and am president of the Canadian Granite Co., which was organised about three years ago with a capital of $50,000, all paid up. We have works in Ottawa for manufacturing granite and marble for the wholesale and retail trade. Our plant consists of sawing apparatus, rubbing beds and turning lathes; we have also polishing jennies and machinery of that description such as is necessary for the purpose of working marble and granite. We employ about 45 men. We own a granite quarry at Kingston, acquired in 1884, being about 18 acres. It was opened some three years ago, seven or eight months after it was acquired. The shipping facilities are very good indeed; we ship on the Rideau canal to our works here, which are on the canal wharf. The color of the granite is a dark red, varied by dark and black spots; it is an eruptive granite and is very hard. There are some particles of mica in it; some call it a syenite. The mica is in very small particles. All the granite down the St. Lawrence is dark red, and that on the American side is very much darker than ours. There are a great many natural seams, and that is the difficulty; perhaps if we get down to a considerable depth that may improve, but we cannot say as yet that there is any improvement. We have got out some very large blocks, but the waste is very considerable. This granite takes a beautiful polish, better than any I ever saw. It is worth from 15 to 20 per cent. more than the ordinary granite to cut. It is used for ornamental purposes, columns for buildings, etc. There is a good demand for our product, but the price owing to Scotch and New Brunswick competition is very low. In the old country they have a good deal of surplus stock, and the shipping facilities are entirely in their favor. They can ship Aberdeen granite in any quantity they require from Glasgow, even single orders to gravestone men. They can deliver to western Ontario men for about the same freight as we can here,

Canadian Granite company.

although we have very good shipping facilities as far as distribution is concerned. I cannot tell you the number of tons we have brought down from Kingston. We have brought a good many barges full, some for ornamental and monumental stock, some for paving blocks, and some for granolithic pavement. The Granolithic company is mainly made up of the shareholders of our company. We have about 150,000 paving blocks on hand, worth about $80 a thousand. We have sold some of these granite blocks in Montreal, and some in Ottawa; the demand for them is increasing. The polished granite is sold throughout the country. What we sell around here pays us better than what we ship, as we get the retail price. We have sent a little to Chicago. Very little of the American granite comes into competition with us. At the quarry we are about shut down at present. At the mill the number of men employed is 45. During the summer we have 25 or 30 men at the quarry, but in the winter we only keep 3 or 4. We have a marble quarry at Renfrew and one in the township of Templeton, Quebec. We have leased the Renfrew property and we get from it what is commonly known as the Renfrew marble; it is a crystalline marble. We leased that about three years ago. Since we have had it we have taken considerable out. We do not work it steadily; we just take out the quantity that we require. We use it for monumental material, slabs, copings, window sills, trimmings, and for such purposes. It is an excellent stone and takes a good polish. It is a degree harder than the ordinary limestone, and is not as liable to stain as the ordinary white marble. The other property we are working is a serpentine; it is in the province of Quebec. There is serpentine in this province, but I don't know of any that is being worked. In this province the quality is very fine, finer than anything I have seen; but the difficulty is to get the sizes, as it is all broken up. The Templeton quarry is about 18 miles from here, and the cost of bringing the marble from it is about the same as bringing the stone from Kingston. There is no serpentine in Ontario as near to us as that. There is fine serpentine between here and Chat's rapids and in other places, but there has been no development done.

Manufactured products.

Employes.

The Canadian Granite Co.'s marble quarry at Renfrew.

Serpentine.

W. S. Gibbon—In the town of Little Current, towards the western part, there is a large quantity of dolomite. Back of my house there is a quarry of it. It is used for building, and also for making lime of a very fine and strong quality, which sets like cement. This stone is particularly well adapted for building purposes, and the supply is unlimited.

Limestone on Manitoulin island.

S. J. Dawson—At Manitoulin island and St. Joseph's island I understand there are magnificent deposits of limestone.

E. W. Rathbun—At Napanee Mills we own a quarry in connection with our cement mills. As far as we have worked yet we find that there are five or six layers of good cement stone, the aggregate thickness of which would be about four feet, the layers being separated from one another by layers of limestone. The cement stone commences perhaps about two feet from the surface. We commenced work there about ten years ago. In connection with the cement works we employ about 30 men, as regulated by the demand. Some parts of the work are going on constantly, such as the taking out of the rock, burning or grinding. The rock is broken to a uniform size, and then put into the kiln and burned; it next passes through the crushers and grinders, and finally through screens of a certain mesh, when it is fit for the market. Our output last year was about 9,000 barrels, valued at as many dollars. The market is in Ontario, to the Grand Trunk railway company, for public works, etc. Our capacity is equal to 400 or 500 barrels a day. There is no doubt that the cement is first class, for by actual test it stands ahead of the Akron cement. It sets as hard, but not as quickly, as the Portland. The demand for it is increasing; it works well with our terra cotta, making a firm and solid wall by the cement rooting into the porous character of the terra cotta material. We expect it will come more and more into use. Our contracts for 1889 aggregate already three times the output of 1888. About a year ago we started the manufacture of porous terra cotta for building and fire-proof purposes. It is manufactured under American and Canadian patents which we control; we have made great improvements. The clay is mixed with sawdust to an extent governed by the weight and strength we wish to produce. What we find the most useful is a mixture that gives a product about one-third the weight of brick; that is to say a product a square foot of which will not weigh above one-third as much as a square foot of brick. In the process of the manufacture the sawdust is wholly consumed, leaving neither charcoal nor ash. In the burning it forms a chemical combination with lime, etc. The sawdust is altogether consumed, leaving little air spaces therein. The object of having open spaces is for the sake of lightness, dryness

Cement stone and cement works at Napanee Mills.

Porous terra cotta.

and uniformity of temperature. It also deadens sound. After the brick comes out of the mould it is dried and at this season of the year we apply artificial heat. The length of time it takes to dry depends upon the temperature and other conditions. We have tunnels for drying, in which we put through a charge a day; on the drying floors, to which heat is conveyed by steam pipes, it requires several days. We make the terra cotta for several different purposes, such as ceilings, floors, partitions, furring, roofing, etc. When used for roofing it deadens all sound, so that the falling of rain or hail cannot be heard underneath. The roof may be covered with tar paper and asphalt, for nails can be driven into it as firmly as into lumber. It is also well adapted for churches and assembly chambers on account of its acoustic properties. A material of some similarity was used in the largest building in Chicago, the Auditorium. They make the material there softer than our architects would allow it here. The strength required in New York is equal to a pressure of 1,700 lb. to the square foot. A test was recently made in Toronto of our material when 4,545 lb. of pig iron was put on to a square foot of a four feet span, and that without any yielding or sign of weakness. This was perfectly satisfactory to Mr. Waite, the architect of the Government buildings, the Bank of Commerce and the Canada Life building, all in Toronto. Another advantage it possesses is the ease with which it can be handled by workmen. We get the clay for the terra cotta from the same lot from which we get the cement stone at Napanee Mills, where we also get building stone, brick clay, and almost a fire clay from underneath. For this year the value of our product will be about $17,000. Our market is altogether in Canada, and we are satisfied with the progress we have made so far. We have had some very good orders. As our works are at present, we employ 50 men. On White lake, along the Napanee, Tamworth and Quebec railway, there are large beds of marl composed of vegetable matter and shells mixed together; it is found in a plastic state. Mixed with the clay from the cement property it makes a pretty fair Portland cement.

Use of the terra cotta.

Market.

Hewson Murray—I am the president of the Toronto Pressed Brick and Terra Cotta Co. Our company was organised within a year. The amount of the authorised capital is $200,000, of which the paid-up is between $30,000 and $40,000. The property is on the Canadian Pacific railway two miles west of Milton. We have 100 acres. The clay was discovered in the early part of 1887, and it extends over 70 acres. We have gone down about 21 feet and find it to improve as we go down. It is just under the mountain, and on the same lot there are freestone and limestone. We consider that the quantity is inexhaustible, being from 70 to 100 feet deep. The clay is of a reddish color; we understand it does not contain any lime, but there is some magnesia in it. We began work in the spring of this year. We have an engine, boiler and two machines capable each of turning out 20,000 brick a day. The machines are worth about $2,000 each. We use steel moulds. At present we can make about 30,000 a day. We have just about completed our stationary kilns, each of which contain about 120,000 bricks. We are building a shed over the whole five kilns, so that we will be able to work in any weather. The first kiln was lighted in May or June, and the brick was rather light in color. I think we made 300,000 or 400,000 this year. There are four or five houses being built with them, and we have orders for some for warehouses. We have also got an order for 800,000 off-color brick for sewers. The face or pick brick we sell at $20 a thousand. There occur in the deposit beds of white clay that we have not been able as yet quite to separate, but we hope to be able to do so. The clay is crushed, pulverised, and put through our separators so that when it goes into the mould it is like fine dust and perfectly dry. The Canadian Pacific railway passes through the lot and there is a switch to the works. Our superintendent is an Englishman, and he says the clay is as good as any in the States, but he will not admit that it is as good as the English. After the works are up I think a manager and 10 men will run them. The wages are in the neighborhood of $1.25 to $1.50 per day.

Brick and terra cotta works

Machinery.

M. J. Hynes—I am engaged in the manufacture of terra cotta in the city of Toronto. We get our raw material from the township of Toronto, county of Peel, about 20 miles from here. In its natural condition the clay is red and is largely impregnated with oxide of iron. I do not know the depth of the bed, but think it will run 100 feet. We have confined ourselves to the manufacture of ornamental work for the inside and outside of buildings. We commenced work about five years ago, and since that time our business has increased very much. Last year we made about $25,000 worth. Our product has been sold all over Ontario, in Montreal, and as far as the lower provinces. Our market is increasing.

Ornamental terra cotta.

Terra cotta is coming very much into favor, but I do not know that it has been made as yet by anyone except ourselves in Canada. There are potteries all over Canada. The clay they use is imported. The goods we make are protected by a duty of 30 per cent.

Albert Carpenter—The company of which I am a member is the Hamilton and Toronto Sewer Pipe Co. Our stock is $90,000, of which $70,000 is paid up. We are only manufacturing at Hamilton. Besides the clay we get here we use some imported clay which we get from New Jersey and Ohio. That which we get here is quite close to the city, on the west side. We mix the clays in different proportions according to the quality of the pipe we want to make. We think we can make as good pipe without mixing the imported at all, but the trade is prejudiced and requires it to be done. We have had tests made by an engineer, and the pipe made altogether from our own clay was the stronger. The value of our total output has increased within the last two or three years, and is now about $70,000 a year. We employ 40 or 50 men altogether. We pay ordinary laborers $1.50 in summer, skilled labor $1.75 to $2, and some working by the piece make as high as $3 a day. We have two factories in the city. In one we burn wood and in the other coal, but we cannot say yet which is the more economical. The wood we use is pine, and costs about $3 per cord delivered. Our market is in Canada. There is another factory in St. John's, Quebec, in which I had a half interest till about a year ago, that supplies the pipes used in Montreal. We supply from Kingston west, except Toronto. We do not supply more than one-third of the Toronto pipe; all the rest used in that city comes from Scotland and the States. With that exception we sell most that is used in Ontario. Our business has had a steady growth. During the last five years, since I have been connected with the enterprise, operations have doubled. The business is quite satisfactory and pays fairly well.

Clays and sewer pipe.

Outfit and wages.

Markets for the product.

S. S. Mutton—I am interested in a deposit of kaolin at Hamilton. It is just on the border of the city, a mile and a quarter from the city hall. It was formerly the property of Dr. Springer. It is at the base of the mountain and appears as if the pressure of the mountain had driven it out. It is decomposed felspar Last week ten cars of it were sent to some crockery concern in Chicago. There was an analysis made by the government analyst at Ottawa, and he reported it free from iron or lime. It is useful for making ornamental articles and crockery. Mr. Plant of Carleton has tested this clay and pronounces very favorably upon it. I took some of it to New York and they said it was kaolin and a very good article. A man from St. Louis said that he had never seen as good except at some place in Texas.

Clay or kaolin.

Charles Taylor—My business is that of engineer. At present I live at Bridgewater, Ontario. For the last twenty-five years I have been interested in mining in Nova Scotia and Ontario. In Nova Scotia I was employed by the London Gold Mining Co. as superintendent of their works, and I erected the first crusher in that part of the country. I came to this part of Ontario about six years ago from Montreal. Directly or indirectly I have been engaged in mining operations for about twenty-five years. I have been working the actinolite mills at Bridgewater. I put up the works there, and I have three patents on the process, one for breaking the stone, one for pulverising, and the other for a composition for roofing. The actinolite occurs diagonally in the vein, at an angle of about 40 degrees. We get it sometimes in veins, sometimes in pockets; some of the pockets are from 10 to 12 feet broad, and where found in pockets it is generally in prisms. It seems to be associated in an upheaval between the dolomite and the gneiss or trap. On the east side is a conglomerate of limestone and quartz pebbles, with a matrix of limestone; next the conglomerate is slate then magnesian rock, and then the gneiss again. There is no trap near the actinolite itself. I have seen actinolite occurrences in other parts of the country, but only on the same range of rocks; I have not seen them in any other range. This is the only place I have seen it in Ontario. I have seen it in the province of Quebec; but there it does not occur in the same manner, being associated with asbestos. We get different kinds of actinolite; one kind is long, another comes up in prisms from one-half or five-eighths of an inch to six inches long. It is all the same when ground. We have not found any asbestos. I think the present source of supply may become exhausted without regular mining and a great deal of expense. During the six years I have been in the business we have sent away from our place about $6,000 worth a year. The actinolite is first broken up, then it is pulverised, then it is ground into dust, except that the live fiber is drawn the same as paper pulp; that absorbs the tar and it consolidates.

Actinolite or fibrous serpentine.

We mix it up with tar the same as mortar, and it can be put on the same as mortar. What we ship from the factory we do not mix with tar; we sell it in a pulverised state. It is put up in bags containing 100 pounds; one bag contains enough for 10 feet square of roofing and the price per bag is 75 cents. It takes about 30 horse-power to drive the machinery for grinding 25 to 30 tons a day. We use water power altogether. Our mill runs about six or eight weeks in the year, and we find a market for our product in Canada and the States. We always have orders ahead, and this year we could not fill all the orders because we had not sufficient water. In addition to roofing our product is used for sidewalks and the foundations of houses. It does not crack or shrink, and it is fireproof. The tar will burn a little, but that forms as a crust; it is a non-conductor. At our mills we employ sometimes as many as 16 or 17 teams. Five men are employed in the mill, and at other times the same men work in the mine. We pay $1.25 a day to men, and $2.50 for teams. The duty entering the States is 10 per cent. because it is not a finished article; that amounts to about $1.50 a ton. The raw material costs us about $3 a ton.

Market for the product.

Joseph James—I am in partnership with Mr. Taylor in the actinolite business, which is now in liquidation. The capital invested is about $17,000 or $18,000. Mr. Taylor's share is about $3,000. The cement we manufacture is made for roofing. It is altogether different from any other kind of cement; it is the only one using actinolite or fiber to make the bond; the others use mica for that purpose. We also grind cement in which mica is used as a further bond, and I think this is an improvement. As the trade get it, it is ground to about 60-mesh; it is mixed with coal tar and pitch, and sometimes asphalt, according to the quality of the roofing desired. It is spread on the roof while hot, the total thickness including the felt on which it is spread being half an inch. This roofing never gets hard; it remains elastic, and will bend to a limited extent without cracking. Our patent covers the use of actinolite with coal tar or its chemical equivalent. The process of laying it is not a patent, only the materials. The cost is about the same as a good gravel roof, and it is more durable and better in every respect. The coal tar or pitch is hermetically sealed in the material, and cannot possibly evaporate or dry up. The sun or the frost will not affect it. It is as fireproof as a roof can be; more so than any metal roof. Insurance companies take it as a first class roof. It has another advantage over metal roofs besides being much less expensive; it is not affected by coal gas in cities, as is the case with metal roofs, particularly in foggy weather. The proportion in mixing is 11 gallons of coal tar or its equivalent to 100 pounds of actinolite. It is infusible; it can be softened by heat, but cannot burn. I grind some mica for the Grand Trunk to use as a lubricator. The first cement was made here in June, 1883, since that time there has been turned out about 50,000 bags of 100 lb. each. Last year was our smallest year's business, owing to trouble among ourselves. It is now four years since any endeavor was made to extend the business, but I think it is capable of being extended largely. Our principal markets are Montreal, Chicago and Detroit. I am satisfied with Taylor's pulveriser; I don't know of anything to beat it. I can put through 25 tons a day of ordinary rock, 12 hours work and 2,300 revolutions to the minute. It will grind 20 tons of phosphate in ten hours. Working easily it will do about 1½ tons of the actinolite an hour. I would recommend it as the best grinder I know. I have seen it grinding bones in the Montreal abattoir. It will do about the same amount of quartz as of phosphate. The vein on lot 7 in the 1st concession of Kaladar is 10 or 12 inches wide on the surface. We have gone down 23 feet, and it is about from 2½ to 4 feet wide. I think it is a vein there, because I never found it in any place else to that depth. Our material costs us from $1 to $5 a ton.

Roofing material.

E. B. Fralick—I am interested in the slate property on the north-west corner of lot 5 in the 6th concession of Madoc, being about five acres in extent. The slate is of a grey color and is like the Scotch and Welsh slate. The cleavage is very superior and its strength very great. As far as we got, it was too hard to make roofing slate to pay. We were above what is called the waterline; to get good slate we would have to go below the action of the air and weather. We went down about 40 feet. It would cleave to the thickness of roofing slate, but not so thin as the Rockland slate in the province of Quebec; but ours would stand a test as to strength better than the Rockland. We made some into flags, and these stand the weather well without scaling on exposure. I think the whole band could be used in the manufacture of flagging, mantels, etc. The color is a very

Slate.

nice grey and is uniform. We have not tried to polish it. We could get cubes as large as 12 or 14 feet long by 2 wide. We could get ordinary flagging slate 4 by 2½. The extent of our quarry is about five acres. We have not organised a joint stock company, but we began work in June, 1880, and expended from $500 to $700 a month till the cold weather about the middle of November. We expended about $6,500 upon the work. The opening must be 45 feet long by 30 or 40 feet wide, and about 35 feet deep. Our stone was valuable for flagging from the very top. We found a market, but could not get machinery to cut our blocks into the proper shape. The mistake we made was making roofing slate, of which we made considerable quantities. We thought we could control the whole of the market of western Ontario for roofing slate; but we could not make proper roofing slate if we had the orders, as we were not far enough down to get the proper slate. Had we begun by making flagging we could have got a market in Canada. The duty going into the States is $15 a ton, and therefore too high to allow of a market being found there.

CHARCOAL.

Deseronto charcoal works.

The Commission visited the charcoal ovens of the Rathbun company at Deseronto. These are constructed on the ordinary beehive pattern, with some modification in the flue arrangement, and they manufacture several bye-products as well as charcoal. The ovens are eight in number, each holding 50 to 55 cords of wood, and the yield per cord is stated to be 50 bushels of charcoal, 8,000 to 10,000 cubic feet of gas and 4 barrels of liquid. The liquid is used in the manufacture of wood alcohol, acetate of lime, sugar of lead, dyeing material, etc. The works produced last year 75,000 bushels of charcoal. The charcoal producing district of Essex was not visited, but it is understood that the coal made there is used nearly altogether by the Detroit smelting furnaces.

Essex charcoal works.

COPPER AND NICKEL.

Locations.

The only copper locations visited by the Commission were in the Huronian formation, occurring either in quartz veins, as at Bruce Mines and Echo lake, or in large deposits and in strong belts like iron ranges, as in the vicinity of Sudbury. The occurrences at Michipicoten and Mamainse in the copper bearing series were not visited, and reference must be made to the evidence for information concerning these.

The Sudbury mines.

In the neighborhood of Sudbury, on the line of the Canadian Pacific railway, very important developments have recently been made to the north-east and south-west of that town, stretching into and beyond Denison township. The rocks as a rule consist of quartzites, chloritic, hornblendic and talcose schists and diorites, both coarse and fine grained, the diorites and schists being especially prevalent about Sudbury. The copper occurs in a highly pyroxenic diorite belt, and, as a rule, associated with nickeliferous pyrrhotite, the average composition of the ore being from 3 to 7 per cent. of copper pyrites, 2½ to 3½ per cent. nickel, about 63 per cent. pyrrhotite, and 30 per cent. rock. The ore occurs irregularly in large lenses, dipping south-east, and is also found disseminated through the diorite, with which it has undoubtedly been brought up. The belts can be traced for a long distance through the country, and the ore bodies occur at uncertain intervals. The ore deposits are distinguishable by the red color given to the soil by the decomposed ferruginous matter. The ore is hard, and the ore-lenses as a rule form hills or mounds. Examples are seen (as at the Vermilion copper shaft) where chalcopyrite

Occurence of the copper.

forms veins and masses, with breccia of diorite, and associated with which native copper has been found in leaf form. It is possible that this rich copper ore is due to a secondary action, and has leached or segregated out from the diorite. Free gold has also been found with the diorite in which the copper occurs.

As this district has recently been receiving more notice than any other mining region of the province, it may be of public interest to give a few notes of some of the principal deposits which are now being opened up.

The copper in shaft No. 1 of Vermilion mine, Denison township, occurs in a dioritic copper-carrying band running east and west. At the point where the shaft has been sunk the rock is highly pyroxenic and with quartz stringers. Free gold is visible in places. The diorite carries copper pyrites disseminated through it, but here a fissure has formed (to what extent not yet determined) running in a north-east and south-west direction, and dipping 65° to the south-east. This is filled with a mass of rich copper pyrites, the surface of which is coated with grey copper sulphide somewhat decomposed and soft. Native copper is also found in fern-like leaves in a thin flucan vein cutting in from the south-east and dipping at a low angle to the north-west. Native copper also occurs in grains in crystalline hornblende rock, but in very small quantities. The copper ore occurs, as before stated, in a pure mass surrounding rock masses and breccia in the vein, and also in joints and cracks of the diorite, having apparently been separated out of the diorite. Iron pyrites occurs, but not to any great extent, and also some galena and nickeliferous pyrrhotite. The upper part of the deposit has decomposed to a red gossan, which treated at the stamp mill is said to yield gold and sperrylite, an alloy of platinum and other metals of that group with arsenic. A stringer of quartz with copper pyrites runs into the shaft from the north-west side, while on the south-east side of the shaft the copper pyrites is fifteen to twenty feet across. Vermilion mine.

The outcrop of copper on the Krean location, lot 5 on the 5th concession of Denison, is an example of the established copper belt which can be traced for a long distance. The hill is stained and covered with red gossan from decomposed pyrites, extending for 50 yards across the strike of the belt, which runs in an easterly and westerly direction. It consists of pyroxenic rock and breccia of the same, cemented by copper pyrites and some quartz veins. The pyroxene rock varies in texture from coarsely crystalline (sometimes with felspar) to a closely grained dioritic rock. A close-grained quartzite or felspathic rock occurs on the north-west side of the deposit. Krean's location.

The Stobie mine is the property of the Canadian Copper company, and is located in a copper belt which runs north-east and south-west through the townships of McKim and Blezard, cutting through the south-east corner of the latter. The ore occurs in a highly pyroxenic diorite, similiar to that seen with the copper in Denison township, in great masses of solid ore and disseminated through the diorite. It consists of a mass of nickeliferous pyrrhotite carrying copper pyrites. An open cut has been run north 70° west forty feet Stobie mine.

across; the bottom is filled with water, but the end is solid ore, as are also the exposed sides. A hill rises some 75 feet on the west side, from which ore is being quarried. A level has been run north 70° west for 60 feet into this hill, and on the north side of the level ore is exposed all the way. On the south side of this level rock was seen for 24 feet, coming in at about 10 feet from the entrance. There is therefore more than 100 feet chiefly of ore exposed across the strike, dipping 45° to north-west. See Fig. 5. It is reported to carry $3\frac{1}{2}$ per cent. nickel, 3 per cent. copper, 40 per cent. iron, 25 per cent. sulphur, and 28.5 per cent. rock matter, or in other words $71\frac{1}{2}$ per cent. metal and $28\frac{1}{2}$ per cent. rock. It was stated in evidence that a shipment to London and New York was dressed up to 7 per cent. copper and contained 3 per cent. nickel.

FIG. 5.—*a. Ore. e. Earth.*

Copper-cliff mine.

Copper-cliff mine, also the property of the Canadian Copper company, lies to the south-west of Sudbury, and is therefore probably on the same copper belt as the Stobie mine. The ore and rock mass form a ferruginous colored hill, on the southerly side of which a large amount of ore has been excavated, and a shaft has been sunk at 45° to the north to a depth of 312 feet.* At each 100 feet levels have been run east and west, the greater mass of ore being found towards the east. Cross-cuts have been driven at frequent intervals, in one case running into quartzite to the north. Some of the levels are run in the rock, but a great deal of ore has been opened up, occuring in shoots or irregular masses. The composition of the ore is the same as that of the Stobie, with the exception that there is more of a crystalline pyrrhotite which is said to run higher in nickel than the average. It is broken with a Blake crusher and then hand-picked. The country rock to the south-east of the pyroxenic diorite band is a chloritic shale, with brecciated masses and segregated crystals occuring in places through it.

Evans mine.

The Evans mine, which is also the property of the Canadian Copper company, lies a little west of south from Copper-cliff, and about one mile distant from it. A ferruginous mound, but of smaller dimensions than the others' marks its location. A diamond drill was put down a depth of 130 feet in ore all the way, and a shaft had been sunk 85 feet at the time of our visit. Here and there the diorite comes in, dipping south-east across the shaft, but for the most part the shaft passes through solid ore. The shaft is 12 by 7 feet inside measurement. A very good ore-house for crusher, screens and ore-pockets has been erected over it. The ore is similar to that of the Stobie and Copper-cliff mines, being a nickeliferous pyrrhotite and occurring in like manner. It may be distinguished from that of the other mines, however, in that it has a spotted appearance, due to the regular dispersion of the different minerals, but the ores of all three mines are apparently of a nearly uniform richness. The dioritic rock alongside the ore bodies contains

* On the 1st of June, 1889, the shaft had reached a depth of 435 feet.

pyrites spotted through it, as is the case also for the most part with the diorite similarly situated in the other mines.

At the Wallace mine location on the north shore of lake Huron, a short distance west of the mouth of Whitefish river, the strike of the rocks is a little north of east and south of west. The location, known as Montalba, consists of 1,600 acres. The rocks are quartzose shales and diorites, varying in places from close-grained and compact to shaly. Some copper pyrites and nickeliferous arsenical pyrites occur in the diorite, and in the quartz stringers in it. Two shafts were sunk many years ago at some 50 yards apart in the diorite. Both were filled with water, and there is no evidence among the dump piles of any ore of value. About half a mile to the west on the same property, around a point of land, another shaft has been sunk in chloritic schists and diorite. Some particles of copper pyrites are to be seen in the rock at the dump, but otherwise no sign of vein or vein matter or ore of any value. It may be said that at the places visited by us on this property there appeared to be small masses of copper pyrites and iron pyrites, and in one place some nickeliferous and arsenical iron pyrites in a quartz stringer in dioritic rocks, chloritic schist, and to a less extent in quartzite, but we were unable to detect any satisfactory sign of a permanent vein, or of segregated masses of mineral matter, although such veins are described in Logan's Geology of 1863. Either information given by interested parties was published in the report, or we did not visit the right localities.

Wa location.

The quartz veins carrying copper ore which occur in the Huronian formation are well illustrated at Bruce Mines, where strong ones occur in the greenstone or diorite. These veins are fully reported on in Sir William Logan's report of 1849, from which the plan of the lodes is taken. (Fig. 6.)

Bruce and Wellington mines.

FIG. 6.—Map of the Bruce Mines region.

The veins are 6 to 20 feet wide, and near the crusher mill an open cut in the vein shows a width of 15 feet. It is said they can be traced $2\frac{1}{2}$ miles on the surface, and that they do not diminish in width at the lowest point reached, about 440 feet. They carry $4\frac{1}{2}$ per cent. of yellow copper pyrites, and a very little iron pyrites. The property is variously reported to have yielded $2,500,000 to $7,000,000 worth of copper. Important evidence relating to the history of the Bruce and Wellington mines has been procured by the Commission.

Another example of a quartz vein carrying copper is seen at Echo lake, on the property of the Austin mining company. A strong vein 9 feet wide

Austin mine.

runs north and south between chloritic schists on the west side and quartzite on the east side, the latter of which is replaced by a band of felspathic diorite. It would appear as if the vein had been formed in a large fault. A tunnel about 6 feet across and 7 feet high has been driven upon the north and south vein, the walls of which appear to be well defined. Another vein on the same property is seen striking east and west, although Captain Williams thinks that the north and south has in reality twisted to the west. At the junction of the two veins, or at the greatest angle of deflection if twisted, a shaft has been sunk. The matter on the dump of this shaft is chiefly quartz vein rock without mineral, but there are some 20 or 30 tons of ore which could be stamped carrying yellow copper and iron pyrites. Several other small exploratory shafts have also been sunk upon the vein or veins. Figures 7 and 8 are plan and section of this property, furnished by Mr. George F. Austin, C.E.

FIG. 7. Map of Austin mine location.

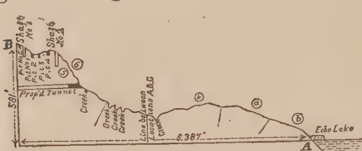


FIG. 8. Contour of Austin mine location. 5. *Chloritic shales.* 6. *Quartzite.*

E. B. Borron—I am stipendiary magistrate for northern Nipissing. My profession proper is mining. I had fourteen years experience in Scotland, and since 1850, when I came to America, I have been mostly engaged in mining and exploring. In 1852 I went to the Bruce mines as general manager, and was there till the latter end of 1857; I then returned to Scotland to take the management of the mines at Leadhills, with which I had been connected before. There I remained till the mines were sold, shortly after which I returned to Canada (in 1862) and spent some time in exploring on the north shore of lake Huron. I was appointed mining inspector for the Lake Superior mining division under the General Mining Act of 1869, and retained that position till 1873, when I resigned. From 1874 till 1878 I represented the district of Algoma in the Dominion House of Commons, declining renomination in 1878. I was appointed stipendiary magistrate for northern Nipissing in 1879, since which I have been employed in the summer season chiefly in the exploration of that region, better known as the disputed territory. It would appear from what are called Indian diggings that the existence of native copper on both shores of lake Superior must have been known to some of the inhabitants of this continent in very remote times. The only localities where these diggings have been found on the north shore are, so far as I know, at cape Mamainse and upon isle Royal. Although the occurence of native copper on both sides of lake Superior was mentioned a century before in the narrations of the Jesuit missionaries, it was not till the year 1770 that we hear of any active mining operations by Europeans. We learn that some three years before that date one Alexander Henry, an Englishman, engaged in trading with the Indians, had passed the winter on Michipicoten island and reported the existence of lead at Mamainse and of the grey ore of copper at that and various other places. In the year following, 1768, Captain Carver hazarded the prediction that "in future times an advantageous trade in copper will spring up." So far, taking in both shores, the gallant captain was a prophet; but in view of the magnificent canal and locks since completed, how primitive were his notions as to the best way of accomplishing this! For he goes on to say, "The metal will be conveyed in canoes through the falls of Ste. Marie, and thence in larger vessels to the falls of Niagara, and after being carried by land across the portage will easily be transported to Quebec." In 1770 Henry formed a company, in which the Duke of Gloucester and other prominen

Copper mining in the Lake Superior and Lake Huron districts.

Early and unsuccessful ventures of an English company.

Englishmen were partners, to work mines on lake Superior. They had a shipyard, it is said, at Point aux Pines, about six miles above Ste. Marie, where they built a sloop of forty tons. A party of miners were in the first instance sent to Ontonagon river on the south shore, where it would seem to have met with no success. The force was then transferred to the north shore, somewhere it is thought about Pointe aux Mines or Mica bay. Here they sank thirty feet in the solid rock, but the vein, which at the surface was four feet in breadth, had, it is said, contracted in the bottom of the shaft to four inches, and under these discouraging circumstances further mining operations were abandoned. In one narrative it is stated that the shaft caved in and killed some of the miners, and that this, together with the difficulty and expense of transporting supplies, led to the abandonment of the enterprise. From other sources we learn that the drift which the miners were driving in soft ground caved in, owing to their neglecting to timber it properly. It is unlikely that such an accident would occur to a shaft sunk in the solid rock and not more than thirty feet deep. This circumstance, taken in conjunction with the fact that many other veins presenting a good appearance at the surface, in that section of the country, have subsequently been found to fail and become worthless at a comparatively shallow depth, leads me to think that the first account is the true one. Henry remarks that it was partly in hopes of finding silver in sufficient abundance to make the speculation profitable that the works were commenced. To Dr. Douglas Houghton, state geologist of Michigan, belongs the merit of being the first to explore, and in his report for 1841 to make known the leading features of the region on the south side of lake Superior, and to give reliable and definite information with regard to the rich deposits of native copper. With the enterprise so strongly characteristic of our neighbors, no sooner had the Indian title been extinguished (1843), than a vast number of applications were made for tracts of mineral land, and the work for both exploration and development was carried on with great vigor, and in some instances with remarkable success. From the year 1773 till 1845 no mining whatever was done, as far as I know, on either the north shore of lake Superior or lake Huron. About the latter date, however, the attention of Canadians having been aroused by the richness of some of the veins discovered on the south shore, they began to form companies with the view of exploring for and working the mineral deposits on the north shore, which it was thought might prove as rich as those on the American side. Among others was the Montreal mining company. The first steps towards the organisation of this enterprising company were taken, I believe, in 1845, for I find on reference to a few rough notes taken from the annual reports that Mr. Forrest Sheppard left Montreal with a small party on May 2nd, 1846, for lake Superior to explore for and locate mineral land for the company. This was followed by another and larger party on the 8th of that month. The whole, when ultimately assembled on lake Superior, numbered between eighty and ninety persons, and were under the charge of Mr. Sheppard, who had been highly recommended as well qualified for the position. The coast from Sault Ste. Marie to Pigeon river, upwards of 500 miles in length, was surveyed and more or less carefully explored. That the company were very sanguine as to the importance of the results of this costly expedition, and the great value of the mineral tracts thus acquired by them, is evident from the first annual report of the trustees, wherein the north shore is described as a "region abounding in mineral treasures requiring only the hand of the miner to convert it into a source of perhaps inexhaustible wealth." Mr. Sheppard selected eighteen tracts, or mining locations, as we call them. Each tract was, in terms of the Crown Lands regulations of that day, five miles in depth by two in width, and contained ten square miles of land. These, with one or two exceptions, were all obtained from the Government. The price then charged was, I believe, £150 Halifax currency paid down for each location, and 4s. or 80 cents an acre, payable by instalments. I think, however, that the company obtained their land for 20 cents an acre. In 1847 the company's operations were confined to a re-examination of the locations on lake Superior and to testing the veins upon several of them, in addition to which the coast of lake Huron was explored from Sault Ste. Marie to Lacloche, and several other mining locations applied for, which, however, were subsequently abandoned. The company was greatly disappointed with the results of both the re-examination and the work done on their lake Superior locations. They had failed to realise the hopes raised by the explorations of the previous season, and the directors naturally, but somewhat hastily, as it appears to me, blamed Mr. Sheppard for his selection, and the men who were employed to test the veins on the locations for their supposed incompetence. In justice to Mr. Sheppard it is only right to mention that

Exploration of northern Michigan.

Montreal mining company.

Exploring the north shore of lake Superior.

The company disappointed.

twenty-one years later the celebrated Silver Islet vein was found to be include within the limits of one of the locations selected by him, and for aught we know other veins quite as valuable may be found in other locations. It was in this year that rich copper veins were discovered on what were afterwards known as the Bruce Mines and Copper Bay locations. The Montreal company, by the advice of their manager, Captain Roberts, an experienced miner who had been brought out from the United Kingdom, purchased the Bruce Mines location. So strongly was Captain Roberts convinced of its value that he recommended the directors to pay as much as £100,000 sterling if it could not be obtained for a smaller sum. The amount actually paid was, I believe, about £40,000 Halifax currency. The company had previous to this completed its organisation and obtained a charter, but after the purchase of this property the stock was raised from 40,000 to 60,000 shares of £5 currency each, and the whole energies and means of the company were thereafter concentrated on the Bruce mines. In the three following years, 1848-49-50, work at the mines, both underground and upon the surface, was prosecuted with great vigor. Dwelling houses sufficient to accommodate several hundred persons, with offices, stores, warehouses, wharves, etc., suitable for mining on a very extensive scale, were built; a powerful engine and ore dressing machinery put in place, and large copper-smelting and refining works erected. Shafts had been sunk, levels driven, and a large quantity of ground stoped, the ore or produce of which was for the most part lying at the surface at midsummer, 1850. A great sum of money had been spent and no returns as yet obtained in a tangible form or shape from the mine. The ore, estimated to contain 6½ per cent. copper as it came from the mine, owing to the expense of transport, was not marketable until dressed or separated from a portion at least of the rock with which it was intermixed. In order to do this a powerful engine and suitable machinery were necessary. These had arrived at the mines from England, together with an engineering expert, in the fall of 1848. This man very imprudently built an engine house of rough or imperfectly hewn stone in the winter, and before spring most of the machinery was in place. The consequence was that as soon as the spring thaw set in this large and costly building fell down. This misfortune, and a severe visitation of cholera in 1849, delayed the completion of the ore dressing machinery and the possibility of obtaining returns until the summer of 1850. The company had now arrived at what may be regarded as the most critical period of its existence. The stockholders had been led to believe that the veins were extraordinarily rich, and that there was sufficient rough ore already mined and at the surface to yield when cleaned some 5,000 tons of dressed ore, worth at least $200,000 or $250,000 net. The opinions, estimates and reports upon which these sanguine beliefs rested were, now that both the ore dressing machinery and smelting works had been completed, to be tested by practical results. In order that nothing might be wanting to ensure success, the president of the company, the late Hon. James Ferrier, went to England and brought out a mining captain, a copper refiner and three furnace men. He also selected a gentleman for manager so highly recommended that the board of directors made an agreement with him for five years. Notwithstanding all these precautions the result of the following year's operations were a sad disappointment to all concerned. The ore dressing machinery was found to be incapable of crushing and cleaning properly more than one-half the quantity of ore the engineers had said it would do. The ore on the surface was found to yield when dressed little more than half the quantity and value that it had been estimated at, and the smelting of the ore by the Welsh process had proved a complete failure. Under these circumstances the anger of the unfortunate stockholders would seem to have fallen on their officers, all of whom either resigned or were dismissed the following year, 1851. In 1852 I was myself appointed manager of the Bruce mines. The mining captains still continued to report that the stopes were producing from two to three and in some instances four tons of 15 per cent. copper ore per fathom. Careful comparison of the total quantity of ground stoped or otherwise excavated, with the number of tons of dressed or marketable ore actually obtained therefrom, convinced me that the veins had not upon an average yielded more than one and a half tons of 15 per cent. copper ore per fathom. Hitherto the miners had worked under what is known in Cornwall as the "tut-work" system. Under this system they are paid according to the quantity of ground cut, but have no interest whatever in the ore. The other system is that under which the miners are paid so much a ton of the dressed ore. In Cornwall it is called working on tribute, and the system under other names and with modifications is adopted in many mines elsewhere. The "tributer" is deeply concerned in the richness of the veins; and while it is his interest in common with

Bruce Mines and Copper Bay locations.

Extravagant management and a sad disappointment.

A change of officers.

Systems of working the mines.

his employer to avoid all waste of ore, it is not his interest unnecessarily to excavate or stope away the wall rock or barren and unproductive portions of the vein. This system I determined, if possible, to introduce. The miners were accordingly offered prices which would have enabled them to have earned considerably higher wages than under the former or tut-work system if the estimates and reports of the mining captains in reference to the productiveness of the various stopes or pitches had not been excessive. All except a few refused to take bargains on the terms offered, and many left the mine rather than do so, most of them asserting that the estimates in question were too sanguine, if not greatly exaggerated. Some twenty miners, however, consented to take contracts in the richer portions of the veins under a modified form of the tribute system, at prices based upon our own estimates. By thus reducing the mining expenditure within narrow and safe limits, and at the same time keeping the ore dressing machinery fully employed cleaning up the poor ores and waste, of which there was a considerrble quantity, especially in the form of skimpings or skimmings thrown off in the process of jigging, it appeared to me quite feasible to make returns which would for several years at least exceed the expenditure. This policy I concluded to carry out with the approbation of the president, then Mr. Hugh Allan, hop ng that in the meantime some improvement in the mine, increase in the price of copper, or reduction in the cost of producing and transporting the ores to market, might enable us to render a favorable balance permanent. Expectations were so far realised that in 1853 the directors felt justified in declaring a small dividend, followed by a larger one in 1854. In this the board, as afterwards appeared, acted precipitately, being moved thereto rather by what was hoped for and expected than by what had been really accomplished. I was myself sanguine that the returns in these first years of my management would exceed the expenditure, and although I did not advise that step, my reports may unintentionally have led in some measure to its being taken. In 1853 and 1854 the price of copper was exceedingly high, and I was strongly urged by the president to increase the output of the mine to its utmost capacity. To do this we were obliged to resort to the tut-work system again, as a limited number of miners only were willing to work on tribute. The result was again most unsatisfactory, and a serious loss was sustained in 1854 and 1855. This loss was owing to the necessity we were under of working the poorer stopes, and to the very high wages we were obliged to pay both miners and laborers in consequence of the demand for men not only at the mines on the south shore of lake Superior but at Sault Ste. Marie, where the canal was at that time under construction. It was however greatly aggravated by the total loss of the company's steamer late in the fall of 1854, with nearly all the materials and machinery required for mining and ore dressing operations during the winter—a loss which could not be fully replaced before the following summer. It may be proper to mention that in 1853 I began to fear that the veins were becoming poorer, and that if they fell off generally as much as they had done in several of the deeper shafts they would soon become unworkable. These opinions were represented to the president, and I urged him repeatedly in the interest of the stockholders to sell the mine if anything like a reasonable offer could be obtained for it. This at length he attempted to do, but the price asked was so high that no one would even look at it. It was perhaps in anticipation of being placed in a better position to dispose of the mines on good terms that the president was led to advise the payment of a dividend in 1854. In the summer of 1855 the tribute system was again adopted and the mining operations on a limited scale were thus carried on without much loss I think till about 1864 or 1865, when the whole location was sold to the West Canada mining company, who had for ten years rented the western portion of it. In 1870 the Montreal company sold the whole of their immense lake Superior property, inclusive of Silver islet. This unlucky sale was, I believe, brought about partly in the fear that the silver ore, of the existence of which they were fully aware, was a superficial or surface show only and would not go down to any considerable depth, and partly in the belief that situated as the vein was below the water of lake Superior it would be exceedingly difficult if not impossible to work it, and that at any rate a large sum would have to be raised and expended and might possibly be lost; in addition to which they were threatened with law suits in regard to their title. Still if the patience and the means of the company had not been exhausted by twenty years of unsuccessful effort at Bruce Mines they would undoubtedly I think have retained and worked Silver islet and been, if the reports of the working of that mine are to be credited, amply compensated for their previous losses and disappointments. In view of the fact that its directorate has included many of the shrewdest and most upright

Results of an economical method.

A reverse of fortune.

The property transferred to the West Canada company.

The Montreal company sells its lake Superior property.

Silver islet.

and honorable merchants and professional men in the city of Montreal, and that its officers have been men of at least average intelligence and experience, results so disastrous to the stockholders and discouraging to others call for explanation. There are several reasons why, in my opinion, the Bruce mines failed to realise the sanguine expectations of the company. The veins on the surface were large and showy, containing more or less of the rich grey and purple ores of copper in addition to the common yellow ore. The gangue of the veins throughout which the ore was distributed was a pure white quartz, and the whole doubtless presented a very fine appearance. Captain Roberts on first seeing the location reported as follows: "This vast deposit of copper ore at the outcrop of the veins is incalculable and almost unparalleled. It exceeds anything I have seen or heard of in Europe." Whether from a failure in the richness or in the quantity of the ore, or in both, we find that Captain Roberts one year later had modified or changed his opinions. There is no doubt that the rich grey and horseflesh ores gave place to the poorer yellow ore at a very insignificant depth, and it is probable even that in this short time the veins in some of the stopes had become less productive. A very careful examination of the mine by the late Sir William Logan at this time (1848) went to show however that the veins were still so rich that on the assumption that there was no further falling off in their productiveness, and that all the copper could be obtained in a marketable condition, a large profit might in his opinion still be realised from the mines. But it was in these very assumptions that the chief obstacles to the realisation of the profit lay. So intimately blended was the ore with the matrix of the veins, and so inconsiderable the difference of specific gravity, that by no ore-dressing machinery or process of separation by water then known was it practicable to obtain in a marketable state anything like all the copper contained in the rough ore or vein stuff as brought from the mine. In attempting to dress the ore to yield 15 per cent. of copper or upwards, not less than two-fifths of it I believe was lost in the deads or skimmings and in the slimes. Again as regards the deterioration of the veins, there can be no question whatever that they became poorer and less productive in depth, and that at a relatively shallow depth as compared with veins in other mining countries they ran out or became so poor as to be no longer worth following. Very little work has really been done below the 35-fathom level and the deepest shaft at the Bruce mines was only about 50 fathoms. Thus without attributing to the managers and other officers of the company either incompetence or deliberate misrepresentation, we find in these two facts, namely, (1) the failure of the veins or lodes in depth, and (2) the impossibility of obtaining in a marketable form much more than three-fifths of the copper actually contained in the veins, sufficient explanation of the almost unbroken succession o over-sanguine reports and estimates on the one hand and of disappointed hopes and expectations on the other.

Causes of failure.

Deterioration of the veins below the surface.

The Wellington mine.

In 1853 Mr. Sampson Vivian, a miner of Cornwall, England, who had spent some years in the United States, obtained from the Montreal mining company at a royalty of one-twentieth of the dressed ore a fourteen years lease of the western part of the Bruce Mines location. Several veins had already been discovered, and some little mining done by the Montreal company, but the ore produced being poorer than that got in the eastern part of the location they had not been worked for several years. It was doubtless under the impression that the Bruce mines had been so named in honor of the Scottish patriot, instead of the Earl of Elgin, at that time Governor-General of Canada, that Captain Vivian called his mine the Wellington mine. The ensuing year the lease was assigned to an English company which he had succeeded in forming. It assumed the name of the West Canada mining company, and the general management was entrusted to the well known firm of John Taylor & Sons, of London. Had the company's operations been confined to the lodes or veins of the existence of which they were aware when they commenced, I am persuaded that they would soon have abandoned the enterprise. It was not very long after they had started, however, when a teamster, named George Clarke I think, in searching for strayed cattle accidentally stumbled on a vein previously unknown. A recent bush fire had burned off the moss and vegetable matter, and left the lode exposed at one or two points where it had previously been hidden from view. When uncovered or stripped, this vein and another with which it formed a junction some distance from where it was first discovered proved not only to be much larger and richer than those the company were then working, but far better than those at the Bruce mines which the Montreal company had retained in their own hands. As the uncovering of the veins was proceeded with it became evident to the managers of the West Canada mining company that they would, if they kept their course, cross the western boundary.

The West Canada mining company.

They, accordingly, very judiciously secured a lease of the adjoining Huron Copper-bay location. I can only say generally in regard to this enterprising company's operations that they were, so far as I had an opportunity of judging, carried on in a minerlike manner; such engines, machinery and ore-dressing apparatus as the large experience of the London managers suggested as being calculated to ensure successful results were sent out and erected at the mines. So great were the difficulties, and so heavy was the cost of starting and opening up the mines, that notwithstanding the richness of the veins no dividends were, I believe, declared for the first six or seven years. In the next seven years, however, under the energetic and judicious management of their local agents, Mr. James Bennett and Captain William Plummer, several dividends amounting in the aggregate to a large sum were paid to the shareholders. In view of the early termination of their lease of the Wellington mine the company in 1864 or 1865 purchased the whole location, including the Bruce mines, from the Montreal mining company. The same difficulties which had been found insurmountable by the Montreal mining company and its managers, and under which they had been obliged to succumb, together with lower prices for copper, began to tell with increasing severity on the West Canada company; and in 1867 or 1868 it would appear that the results had not been satisfactory, for at that period Mr. John Taylor, jr., of London, was sent out to examine and report on the property. He spent six weeks at the mines and his report, which was rendered on the 12th of September, 1868, is remarkable not merely for its ability, but for its general fairness. Mr. Taylor clearly apprehended the chief obstacles to the profitable working of the mines when he says: "It is evident that the three main points you have now to contend with are, (1) the very heavy cost of dressing; (2) the great loss of copper under the present system of washing; and (3) the high rate of freight from the mines home to England." He made two sugestions calculated in his opinion to reduce the expenses and economise the waste of copper. These were, (1) to smelt the ore on the spot, (2) to reduce the copper by what is commonly known as the salt process. He himself favored smelting, but as in both the copper would be obtained in a metallic state, he estimated the saving in the item of freight alone would not be less than £7,000 or £8,000 sterling per annum. In addition, however, to the three points specially mentioned, another circumstance only slightly alluded to in Mr. Taylor's report must have begun before this time to exercise an adverse influence on the returns from the mine. No one who saw the size or richness of the veins at or near the surface in 1855-56 could fail to perceive, on perusing that part of the report which describes their appearance in the bottom of the various shafts and stopes in 1868, that there had been a great falling off both in the size and the richness of the veins at the depth of 40 or 50 fathoms. Mining operations continued to be carried on till 1876, when in consequence I presume of the continued unsatisfactory results work was suspended and has not since been resumed. During the mining excitement of 1846-47 a number of other locations were taken up on the north shore of lake Huron. Among them there was one near the mouth of the Whitefish river on which at least one shaft had been sunk to the depth of 10 or 15 fathoms, so far as I could judge from the quantity of stuff produced, for I did not see it when open. It was known as the Wallace mine, and owned by the Upper Canada mining company. The vein contained copper pyrites and ore of nickel, but not in sufficient quantity apparently to justify further expenditure. I am inclined to think this company had a location on Michipicoten island, where considerable work was done on a vein of native copper. Some mining was done at the Emerald mine on the Rankin location, near Sault Ste. Marie. The ore was the yellow ore of copper, and in such quantity that had it been solid, and not so dispersed throughout the gangue of the vein, it would probably have received a more thorough trial. Several locations were also taken up by the late Mr. Killaly and others near Echo lake, on which there were good sized veins. On two of these shafts were sunk, but which I think did not exceed five fathoms. It was the yellow ore in a gangue of white quartz, but so far as I can recollect it would not yield more than 2 per cent. of copper. Some work was also done at the Begley mine on the north side of Batchawana bay, where the yellow ore of copper was found in good quantity but of low grade. At none of these mines, so far as known to me, was any copper dressed and sent to market. The Quebec mining company was a *bona fide* Canadian company, organised about the same time as the Montreal mining company. The locations of this company were all situated on the north shore of lake Superior, and on Michipicoten island, at Point aux Mines or Mica bay. Misled by surface appearances, and to say the least by the imprudent advice of their manager, they appear to have

The Copper-bay location secured.

Obstacles to profitable working.

The Wallace mine.

The Emerald mine.

Locations on Echo lake.

The Quebec mining company's ventures and failure.

commenced operations with great spirit, or rather recklessness ; a large number of substantial and comfortable dwellings for officers and men, and other buildings such as storehouses, offices, blacksmiths' and carpenters' shops were erected ; a good overshot water wheel and ore dressing machinery were also put up ; and to complete all one or two copper smelting furnaces were built. From the large force employed at the mine I should think that a good deal had been done underground as well as on the surface, in the two or three years during which it was worked. In the fall of 1849 the mine was taken possession of for a short time by the Indians, who were dissatisfied because a treaty had not been made with them for the surrender of their rights ; but a treaty was concluded in the following year, and no further trouble was occasioned by them. About this time the company tried to sell the mine in England, and an expert was sent out to examine it. He reported, I have been told, unfavorably. At all events the mine was not sold, and in 1850 or 1851 operations were suspended and have not since been resumed. The Quebec company must have expended more than $100,000, and I have heard that only enough ore was got out to make three or four tons of copper. It is probable that there might be more or less poor ore that would not pay the expense of dressing and smelting. Be this as it may, for I only speak from hearsay in regard to operations prior to 1852, the returns obtained from the mine were unquestionably very small. Some work was done, I believe, on Michipicoten island, but the result was not encouraging and operations were abandoned there also. About the same time a company called the British North American, I think, did some mining at Prince's bay. The object of their search was also copper, but I was told by some of the miners who had worked there that it appeared to them more promising for silver than copper. It also was abandoned about the year 1850. I omitted to mention that in 1856-57 the Montreal Mining Co., on my recommendation, made a cautious trial of their location at point Mamainse, on the north shore of lake Superior. The veins so far as discovered were neither large, regular, nor well defined, but the display of ore on the surface was tempting, consisting as it did of native copper, grey and yellow ores of copper and galena or lead ore. In this last there was some twelve ounces or more of silver to the ton, and native silver was found associated with the native copper. As little as possible was spent on the surface, pending the result of the contemplated mining operations. Considerable costeaning was done and five shafts were sunk to depths varying from 14 to 60 feet on the most promising veins. From one shaft, which was sunk at a point where there had been an Indian digging, about 1,400 lb. of native copper was obtained. The largest piece weighed nearly 600 lb., the biggest mass that had been got on the north shore up to that time, if not since. The vein, from the first small and without regular walls, ran out almost entirely at the depth of 10 fathoms, and as it was costing nearly $200 a fathom to sink the shaft it was stopped at that point. Three other shafts were sunk on different veins on the same trap range as that which produced the native copper, but only grey and yellow copper ores were got, and these not in sufficient quantities to pay, even had there been ore dressing machinery on the spot. The fifth shaft was on a native copper vein on another range of trap some 150 fathoms to the east of that last mentioned—a strong bed of conglomerate being interposed between them. It produced at first some nice pieces of native copper, but at 25 feet in depth the vein was barren of metal, although still ten inches in width and carrying good mineral soils and spars. The vein of silver-lead was too small to warrant the expense of sinking more than a few feet on it. In view of the company's financial condition, and of the fact that a large sum would be necessary to thoroughly test the mine without assured profitable results, operations were suspended in 1857, the amount thus expended being about $5,000. I am under the impression that the Silver Islet company have, since their acquisition of the Montreal Mining Co.'s lake Superior property, done some work on this location, but with what results I am unable to say. Two English companies have engaged in copper mining on the north shore at a comparatively recent date. One of these properties is situated at cape Mamainse, upon a location immediately adjoining that I have just described. The other is on the island of Michipicoten. A large sum of money has been, I believe, spent on both mines, but especially upon that at Mamainse. The shipments of copper have been relatively insignificant. That the results have been unsatisfactory, to the shareholders at least, may be inferred from the circumstance that at both these mines operations have now been suspended. Of the copper mines at Sudbury I am unable to say anything as I have not seen or examined them. This history of copper mining on lakes Superior and Huron really includes all or nearly all that has been done in the province. At least I am not aware of any other part

Prince's Bay location.

Point Mamainse location tested.

Mining at cape Mamainse and Michipicoten island.

Sudbury.

of Ontario where copper mining has been carried on to any extent worth mentioning. That these enterprises have almost without exception resulted disastrously cannot be denied, however conflicting may be the reasons given by different parties before the Comission. Nor can it be denied that it would have been very much better for the stockholders in the various mines if the three million dollars worth of copper obtained therefrom had still remained buried in the bowels of the earth, and the four or five millions worth of gold or its equivalent expended in searching for and mining this copper had remained in their pockets. Other parties may have benefited, but the men, for the most part Canadians, who furnished the capital clearly have not. But should anyone infer from the uniformly disastrous results of these premature mining operations that the mineral resources of Ontario so far as copper is concerned are unimportant, if not worthless, I must beg decidedly to differ from him. In the district of Algoma, from the mouth of French river on lake Huron to Pigeon river on lake Superior, upwards of 400 miles in a straight line and nearly double that distance following the sinuosities of the coast, and from thence northward to the height of land, there is I believe no considerable area in which copper-bearing rocks do not occur. All along the coast, wherever these rocks are exposed to view, strings or veins carrying more or less copper may be found at short intervals. East of Goulais bay the copper, so far as my experience enables me to speak, is always found in the form of sulphurets, chiefly copper pyrites, commonly known as the yellow ore. West of Goulais bay we find the same ores, together with more or less native copper. On almost every considerable lake in the interior indications of copper may be seen if the copper-bearing rocks on the shores be examined carefully, and not unfrequently good sized veins are met with which under more favorable conditions would be considered if not rich at any rate worthy of trial. Supposing this belt in which copper-bearing rocks at least predominate to be no more than 50 miles wide, we have an area of 20,000 square miles of what may be termed copper-bearing country in the district of Algoma alone. It is true that many of the strings or veins are small and irregular, and contain so little copper as to be unworthy of attention, that many in which the appearance at the surface is promising fail at a trifling depth, and that even those veins which have been the largest, most regular and the richest in copper at and near the outcrop have fallen off greatly both in size and regularity, as well as in the quantity and quality of the ore at a depth of from two to three hundred feet. Nevertheless we are confronted by the fact that a small strip of this copper-bearing country, two miles in length by about half a mile in breadth, or one square mile in all, has actually produced between 40,000 and 50,000 tons of dressed copper ore, worth in the English market between two-and-a-half and three million dollars. Nor are the mines on this single section of land, though of course poorer, by any means as yet nearly exhausted. It is not pretended that deposits such as those at the Bruce mines, the Wellington mines and at Sudbury are to be found everywhere in this mineral belt, nor in view of the extent and depth of the loose material under which the veins are in most parts entirely hidden can it be expected that such discoveries will be of very frequent occurrence; but it is safe to assert that in all human probability a great number of such veins or deposits of copper ore do exist in this belt quite as rich as, if not richer than, any of those already discovered, and that from time to time as the country is settled many of them will be found, accidentally or otherwise. I hold therefore that this field of the mineral resources of Ontario is immensely important and valuable; where so much copper in quantity and value has been obtained from such a limited area, how much may not be reasonably expected from the whole of this copper-bearing belt. It may be said, and with some show of reason, that granting many millions of tons of copper ore may be contained in the rocks of this mineral belt, of what possible importance or value can it be to the province if it is so distributed and the difficulty and expense of mining be so great that when obtained the cost of getting the copper shall be found to have exceeded its value. Now although in a sense this may and doubtless does hold good in regard to the present value of the copper in this belt, the prospective value to the province may nevertheless be very great. Were we compelled to mine, dress and send to market this copper under the unfavorable conditions which have hitherto prevailed in this country, experience has demonstrated that it could only be done at a loss. But under the more favorable conditions that will surely obtain in the future it is morally certain that many of these deposits of copper may and will be worked most profitably, and thus prove a source of incalculable wealth to the province. In order to make this clear, let us suppose the Bruce and Wellington mines to have been situated in England, and we shall see how much more favorable the conditions would

A history of failures.

But no cause for discouragement

Extent of the copper-bearing country.

Probability of further discoveries, and prospects of mining under more favorable conditions.

have been. The wages of the miners and the laborers would have been less than one-half, and the cost of mining would have been reduced in like proportion. The dressing of the ores, which in England is done almost entirely by young women and boys, would have not been more than one-third of the cost of that operation in Canada. The expense of transportation to market would not, I consider, have been more than one-tenth of the sum paid for the freight of the ore from Bruce Mines to Liverpool or Swansea; in addition to all which it would not have been necessary to bring up the ores by dressing to more than 8 or 9 per cent. of copper instead of from 15 to 20 per cent., thus saving not only expenses but a very large quantity of copper unavoidably lost in the process. Then again machinery and all kind of stores and materials, timber excepted, would have been very much cheaper in England. From all these circumstances I am convinced that had the vein at the Bruce Mines and the Huron Copper-bay locations or others of the like character and richness been situated in Cornwall, or almost any other part of Europe, they would unquestionably have yielded the fortunate owners very large profits. Now the point I wish to make is this: if our Canadian copper mines be such that if situated in Europe they would have realised very large profits and been considered very valuable, it necessarily follows that so soon as those favorable conditions arrive in Ontario, then at all events if not before will copper-mining in this province become profitable, and the vast deposits of that metal in the copper-bearing belt north and west of the great lakes become in the fullest sense of the term valuable. The conditions most necessary to profitable mining, whether in respect of labor, of materials or of transportation, are being surely if not rapidly evolved in the district in which the mines are situated. No one who has noted the growth of the district of Algoma in population and otherwise during the last 30 or 40 years can fail to perceive that fact. But on broader grounds I hold it to be absolutely certain that sooner or later all the disabilities under which in the past copper mining has labored will be removed, and that this country will stand in just as good a position as England herself in regard to the economical and profitable working of her mines. In addition to cheaper labor than was obtainable on the first opening up of the country, much may be expected from the employment of labor saving machinery in our mines. The use of rock drills worked by steam or water power, the substitution of dynamite and other more powerful explosives for gunpowder, the employment of galvanic batteries or electricity to discharge simultaneously a number of blasts so placed as to produce the greatest possible effect, are all calculated to greatly diminish the cost of mining, even if wages should remain the same. It is possible also that improvements may be made in the smelting or reduction of copper from its ores. In concluding my remarks as to our copper deposits, I would like to add a word of warning to all engaged or about to engage in mining enterprises, especially in districts where the character of the veins at a considerable depth has not been proved. Not a dollar beyond what is absolutely unavoidable should be expended on the surface, however promising the appearance of the outcrop may be, until one or more shafts have been sunk to a depth of at least fifty fathoms and levels driven each way. This is especially necessary where former experience goes to show that the veins frequently become smaller and poorer, if not altogether barren, at a very trifling depth. Surface expenditure is utterly wasted and becomes a dead loss when the mine itself fails. The fewer failures, and the greater number of dividend-paying mines, the more attractive will be the industry to capitalists.

Suppose the mines to be operated economically, as in England.

Conditions necessary to profitable mining.

A word of warning.

William Plummer—I have been connected with mining matters in the lake Superior section for a good many years. I was engaged at the Bruce mines. They began operations over thirty years ago, and continued for about twelve years. It is twenty-one years since I left. There are two mines there, the Bruce and the Wellington. Both are on the same lode, but one is farther west than the other. The Bruce was worked by the old Montreal company, and the Wellington by an English company and English capital, the latter afterwards acquiring the former by purchase. I was sent from England to manage the property. The Montreal company first commenced operations in 1848; they sold out to our company in 1864. Ours was organised, I think, in 1854 or 1855. When I took charge the shafts were only down a few fathoms, and I put down a dozen. We had two principal veins upon the Wellington and three upon the Bruce, I think. The course of the veins was north-west and south-east. In some places they were 3 or 4 feet wide, in others 20 feet; greenstone rock formed the walls on both sides. The vein matter was mostly quartz. The deepest shaft was about 500 feet, but some were not more than 15 fathoms. Some years the aggregate sinking per year of the several shafts, was about 100 fathoms; and the driving of the several levels 156

Bruce and Wellington mines.

Extent of the mining operations.

fathoms, and over 1,500 lineal fathoms of ore stoped out. The average per year of nine years was, of stopings, 1,241 fathoms, sinkings 87 and drivings 113, making an average per year of the nine years, 1,441 fathoms. That is to say, there was a section of the vein taken out equal to a depth of 10 fathoms by a length of 144 on an average for each year. Dykes crossed the veins at different angles, more or less at right angles. They were, I think, of more recent origin than the veins, and I think had a great deal to do with the richness of the veins. When we lost these dykes for a considerable distance the veins were poor. I am quite sure there is still an abundance of ore in that property; the veins have been worked for a mile and a half I think, but there are parts that are still unworked. I know that district very well, and I know that copper occurs in paying quantities. There are lots of other veins besides those on the Wellington property. Diorite greenstone, mostly composed of felspar and hornblende, in grains, is the copper-bearing rock of the district. We employed about 200 men in underground mining. Altogether we had about 350 employed, some being boys. The underground men were paid by contract, and made about $32 or $35 a month. Surface men were paid about $1 a day, and some got more; wages increased later on—I think about 10 or 15 per cent. Once raised, wages could not very well be reduced. We had steam engines for crushing, pumping and hoisting purposes, as well as for dressing. The drills were worked by hand. Some time after I left reduction works were put up, but I canot tell you the value of the plant. The capital subscribed was £200,000, and for a number of years the mines paid very handsomely. I do not think the books of the company can be got, as during my time we had a riot and the men wrecked the offices and destroyed our books; that was in 1863 or 1864. For many years the mines were very productive, and yielded some 2,500 to 3,500 tons of copper ore a year. At the beginning it went 5 per cent., but later it was only 3 per cent.; it grew leaner as we went down. The ore shipped each year would average about 20 or 21 per cent. At first it was shipped to Liverpool, but most of it afterwards was sent to the States, where we continued to have a good market till the war broke out. Then a duty of 5 cents per pound was put on copper, which prevented our selling in the States and injured us materially. We could only ship through the States in bond, and this caused a great deal of trouble, anxiety and expense, and we found great difficulty in working it. Up to that time the American market was better than the English. That lessened the value of the product, and then the price of copper went down to a very low figure, so that about the time we closed it would not pay. I think that $6,000,000 to $7,000,000 was taken out altogether. I was in charge twelve years.

Laborers and rate of wages.

Production and market.

Frank Prout—I am the agent in charge of the Wellington company's property at Bruce Mines. Work was commenced here in 1858. What was known as the old Bruce mines were formerly owned by a Montreal company; that property passed into our hands in 1869. The extent of our property is two miles frontage by five miles deep, 6,400 acres. I cannot from recollection give you the particulars as to the shafts that have been put down; the greatest depth is 420 feet. The vein did not play out at all; it continued good, in fact improving to the end. We did not find any native copper. The veins run south-east and north-west, being quartz in diorite. They are from 6 to 20 feet wide and were pretty uniform throughout; there was very little iron, the gangue being principally quartz and a little spar. The widest point of the vein we worked was 26 feet, where it formed a horse. I cannot say what it cost per ton to mine. We generally paid about $35 a fathom, the ordinary width being 10 or 12 feet; where wider we paid more. It would cost about $1.50 for stoping, and then there was the driving and sinking besides, which cost much more. The directors are John Taylor & Sons, London, Eng. The capital is £40,000 in 40,000 shares. Some changes were made when the chemical works were established, so that it is difficult to tell the exact position. The Huron Copper-bay location was leased and worked by our company for a number of years. D. McDonald was president of that company, but I think he is now dead.

Bruce and Wellington mines.

W. H. Plummer—On the Bruce and Wellington copper locations there were three lodes. The north and west lodes were not far apart; not more than a quarter of a mile, and they were tapped at different points. The work closed down about 1876. In the good times the greater part of the ore was shipped in steamers, and vessels came direct from Swansea. Some was shipped in bags, but more in barrels, as the company had a barrel factory of their own. The bags were for the better class ore, that which was reduced. Three or four ships a year

Shipments of ore.

came from England, and besides that they shipped by the local steamers to Buffalo, Toronto and Montreal. Afterwards it was shipped from Montreal, being carried by rail to there; the company shipped whichever way they got the best rate.

Edward Norris—I live at Sault Ste. Marie and represent the Lake Superior Copper company, whose works are at Mamainse and the head office in London, Eng and. J. A. Hendry was the president when last I heard. Daniel Norris, of Abchurch chambers, London, is the secretary. I do not know the amount of capital. The present company acquired possession from the Lake Superior Native Copper company three years ago last winter. The property is 60 miles up the shore of lake Superior, and consists of 6,400 acres, 640 of which was got from the Kincaid location. Work was commenced by the Lake Superior Native Copper company in 1882. Three shafts were put down, the original No. 2 being afterwards abadoned and made into a ladder-way. The shafts are about 300 yards apart on the vein. No. 2, the one near the lake, is 320 feet, No. 1 is 280 or 300 feet, and the original No. 2 is 60 feet. There are four levels altogether, but I cannot give you the distances. We have two hoisting machines, six 30 horse-power boilers, an air compressor, dressing machinery, a Ball stamp of about 180 tons a day, column jigs, etc. We have also a saw mill and machine shop. The machinery was put up during the summers of 1882 and 1883. Work was stopped about 1884, on account of monetary trouble. I cannot tell you the quantity of ore taken out; there was not a great deal of dressed ore shipped. The country rock at Mamainse is conglomorate of the Nipigon series. The strike is about 10 degrees west of north. The walls on our vein are trap, but the rocks are very irregular; I think the conglomorate forms one wall of our vein, and the trap the other. The width of the vein on the surface is 5 or 6 feet, but it widens below to about 18 feet; that is speaking from recollection; I have not been there for about four years. The percentage of copper varied very much; the last test made showed seven-eighths of one per cent. of native copper. It is a dry mine, all things considered. We never had any difficulty in getting labor; our miners were principally paid by contract, and the price was about $20 a foot for the full size of the shaft, 8 by 20 feet. The price would vary according to the quality of the rock, and this was about the lowest price paid. Ordinary laborers got from $1.25 to $1.50 a day. The greatest number of men employed at our mine was 260, including 75 choppers; that was in the winter of 1883. Something less than 100 of them were miners. In other years I think about 160 men were employed, except the first year, when the number was about 100. The failure was mainly due to extravagant work. We were new hands in this country, and there was too much building in proportion to the amount of mining. We also lost a great deal of money trying to run a passenger boat. The old company went into liquidation three years ago. I believe if they had money enough to go on for three or four months more they would have weathered it. The present company have done no mining, but they acquired the property with a view to work it. It is composed I think chiefly of the old men, though I believe a number of new men were brought into it. All the shares were never issued. The facilities for shipping are not good, but they could be improved by getting a good boat on the route. It would be a great advantage if American boats were allowed to call.

The Mamainse copper mines.

Extent of mining operations.

Machinery.

Labor and wages.

The cause of failure.

Shipping facilities.

H. Trethewey—I was in charge at Mamainse. We were exploring, and did not go on with regular developing. The indications were very good, the highest assays showing 7,000, 15,000 and 20,000 ounces to the ton; that was selected rock. We only got a small pocket and took out about $150 worth. There is silver there in paying quantities. We found native copper, black and red oxide, and grey ore that assayed 69 per cent. copper; we did not find that in large quantities. I believe there is a good property there. The company spent about $25,000 or $30,000. The deepest shaft was 87½ feet and the longest level 350 feet. We sank seven shafts from 35 feet to 87½ feet. The level of 350 feet was driven through a belt of amygdaloid and conglomorate, and the vein was from 4 to 12 feet wide. There was about three-quarters of one per cent. of copper. The 87 foot shaft was on the vein. We traced the vein for half a mile, 12 feet wide. It carried native copper, red oxide, black oxide, green carbonate and native silver. I know of quite a number of veins farther in; they form deep depressions in the rock on the surface. The dykes on the shore run south-east and north-west, and inland some are east and west. The veins which cut the dykes are almost due north and south, and the dip is 45° towards the lake. I believe that to be a good country for grey copper ore and silver.

Minerals at Mamainse mine.

Other veins in the disrict.

J. S. Williams—The Michipicoten mine was originally the property of the Quebec Land and Mining Co., which did a little prospecting along the back of the vein. About 1882 it passed into the hands of the Lake Superior Copper Co., whose headquarters were at London, Eng., their capital being £100,000. I think they began work the same year and carried on for about three years. They sank a main shaft 400 feet—Bonner shaft 400 feet, Batter's shaft 200 feet, Office shaft 65 or 70 feet. They also did a good deal of drifting. No. 1 at 200 feet level was about 600 or 700 feet, No. 2 at 280 feet was 500 feet, and No. 3 at 360 feet was 300 or 400 feet. In Bonner shaft they cross-cutted and drifted about 600 feet. The vein runs nearly east and west in amygdaloid and trap the total depth, dipping south 52° from the vertical. It is composed of quartz, calcite, epidote, iron pyrites and native copper. The latter occurs in masses of from 40 to 50 pounds to minute particles of very fine shot and leaf copper. The mineralised part of the vein is principally on the hanging wall, but occasionally runs through it. The vein ranges in width from three to six feet and is pretty regular as to size, but varies very considerably as to productiveness—at some places poor, at others well charged with copper. A considerable lot was taken out, but no portion of it was dressed and none shipped; it still lies on the dump. The company quit work three or four years ago, owing to exhaustion of funds. The machinery consisted of two pairs of 24-inch Cornish rolls, four pairs of plunger gigs, four buddles for dressing, all driven by a 60 horse-power engine, with four upright boilers. The property was purchased by Mr. Matthews, at that time mayor of Liverpool, who carried on the works about a year and a half. I was superintendent of the works during nine months of that time. The main shaft was sunk a further distance of 200 feet, we put down a winze 55 feet, drifted No. 3 level 150 feet west, No. 4 about 100 feet. About three-quarters of a mile south-east of the old mine a parallel vein of conglomorate exists, still in the amygdaloid and trap, with an average width of seven feet. We sank 40 feet on that vein and tested it with a diamond drill 250 feet; a considerable quantity of native copper was found, and more evenly disseminated than in the old mine. A band of red sandstone underlies the foot-wall of this vein. The vein matter resembles the Calumet and Hecla more than any other I have seen. Mr. Matthews' death occured in June or July, 1887, and the works were shut down at the end of July. This summer Mr. Cozens is acting for the estate and has an American syndicate examining the property. The total area of property is about ten square miles.

The Michipicoten mine.

Workings.

The vein.

Machinery.

A parallel vein tested.

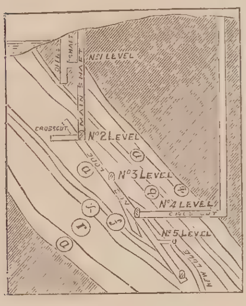


FIG. 9. Quebec mine, Michipicoten island. Scale, 750 ft. to an inch.

a. Trap. r. Conglomerate. r Lode matter with specks of Copper. f. Jasper. q. Amygdaloid.

H. P. McIntosh—My residence is Cleveland, Ohio, and I am secretary and treasurer of the Canadian Copper Co. The company was organised January 5th, 1886; its capital stock is $2,000,000, all subscribed and paid for. The properties of the company are situated in Blezard, Creighton, McKim and Snider townships, district of Algoma, and have a total area of about 10,000 acres. It is difficult to determine which of the prospectors made the first discoveries; at least a dozen diffierent persons were upon these properties about the same time, and we do not know who first found the minerals. The cut through the small deposit on the line of the Canadian Pacific railway, about three miles west of Sudbury, was perhaps the first thing done to call attention to the fact that copper ores existed in the country, but not enough was found there to warrant sufficient expenditures of money to determine its possible value. The ore occurs in a series of parallel lens-shaped deposits in a formation that appears to be principally diorite. The deposits extend more or less prominently through a tract of several miles. The ore is copper pyrites accompanied by considerable pyrrhotite, the latter carrying nickel in greater or less quantities, and the gangue being principally felspar and diorite. It is difficult to get miners and laborers on account of the isolated position occupied by the mines. The men employed are largely Cornish and Welsh, and they are paid monthly in cash.

The Canadian Copper company's property.

Dr. Edward Peters, jr—Openings have been made in the Stobie, Evans and Copper-cliff mines at Sudbury, and at four or five other openings to prove the veins. At Copper-cliff a great deal of work has been done, some $25,000 or $30,000 having been expended. A shaft has been sunk down about 350 feet on the vein, and

The Canadian Copper company's works.

drifts have been run at right angles to the shaft 500 or 600 feet. A great deal of surface quarrying has also been done. On the Evans mine the shaft has been sunk to a depth of 85 feet and two drifts have been commenced, being now about 6 feet. There has also been a small amount of surface quarrying done. At the Stobie two tunnels, each of 30 or 40 feet, have been run in and work has been done as seen by the members of the Commission. At this mine we have a three-drill compressor to work three air drills, a large stone breaker, the necessary pumps, etc. At the Copper-cliff we have a six-drill compressor, a large hoisting engine, a rock breaker, a rock house for separating ore, various pumps and all necessary machinery. At the Evans a three-drill compressor will be put up in about a week, also a breaker, and there will be a very large rock house, one of the finest in the country when it is finished. I think we can dress a good deal of our ore to 20 per cent. Speaking in a wholesale way I think it will show about $2\frac{1}{2}$ per cent. nickel and 3 per cent. copper. The Newfoundland ore is something similar to ours, but does not contain any nickel that I am aware of. It seems to me that the mineral deposits here run through the country something like a string of sausages, with a long space of string between each sausage. As we go down it seems to narrow and then widen out again. There seems to be some connection between the deposits, but I do not think they could be properly called fissure veins; I would call it a mineralised belt, with minerals concentrated in it at certain points. It is a hard region to prospect on account of the broken nature of the country, and owing to the fact that the rocks do not crop up well. If this were in the United States thousands of prospectors would be here on the strength of what has already been done.

Occurrences of the mineral.

Francis Sperry—We have had 10 per cent. nickel in special samples of the Canadian Copper company's mines; that was the highest in the pure pyrrohtite; the average would be 6 per cent. The average in the general body of ore is I think 4 to 5 per cent. copper and 3 to 4 per cent. nickel. In making a shipment we make an analysis; in the shipment to New York it showed 7 per cent. copper and 3 per cent. nickel. That was a shipment of about 3,000 tons. We have on the dumps now about 5,000 tons.

Percentages of copper and nickel.

F. Andrews—I have been in the Sudbury district since the beginning of April. I have been more or less acquainted with mining since I was 13 years of age, both in mining schools and elsewhere. I received my education in Cornwall and Devon, England. I was also at the Royal School of Mines, London. I have had experience in the west, in Mexico, South Africa and Australia. I have been in almost all kinds of mines, except coal mines. I think it is too early yet to give an opinion as to the prospects for mining in the Sudbury district. I cannot say what minerals are in paying quantities, but I am pleased with some parts of the district. The surface deposits are splendid, but there is no deep mine yet to prove how it is below. At the Evans mine they started with the diamond drill at a depth of 130 feet with very satisfactory results, though I do not think the drill is at all a fair test of a mine. At the Copper-cliff they have tested down to about 300 feet, and we will shortly know more about it; it may improve, but I cannot say that it will. I do not know of any other companies besides the Canada Copper Co. and the Vermilion Co. that have done any real work. Prospectors do nothing more than put in a few shots to test the nature of the veins. It is a very hard country to prospect. We employ 32 miners at the Copper-cliff and 12 at the Evans; we work night and day and the shift is ten hours. We have not had any difficulty in getting a supply of skilled labor. We pay outside men \$1.40, miners about \$1.75, and machinists \$2. The shafts and drifts are sunk by contract. Some of those working by contract make as high as \$2.75 and \$3 per day. The rock, particularly at the Evans, is diorite and is very hard to blast. At the Copper-cliff the angle of incline is 45 degrees.

Work at the Canadian Co.'s mines.

James Stobie—In Denison there appears to be more schist accompanying the diorite than at Sudbury. In the No. 1 shaft of the Vermilion the vein is between schist and diorite. Where copper and galena have been found, more or less gold and silver have been found. The course is generally north-east and south-west; there are exceptions however to that, the Lady Macdonald and the Copper-cliff. In these the course is north and south. There is a considerable distance between them, but I think they are a continuation of the same deposit. In some places in the belt the diorite itself is rich enough to be worked; in other places it is not; it varies very much. There seems to be any number of places where, if handled with economy, mining should pay.

Occurrences at Sudbury and Denison.

Robert Hedley—The specimens of copper I examined have not been representative, but I think picked specimens; some have gone very high, as high as 23 and 24 per cent., some 15 and 17 per cent., and some lower. In almost all cases I found nickel associated with the copper, either intimately or lying side by side. I have assayed for nickel and have found from 1 to 25 per cent.; but only as high as 25 per cent. in one case, and that was from the Vermilion shaft No. 1; there was 6 per cent. copper. I have tested for cobalt and found it existed with nickel. With some copper ores I have found gold and silver in small quantities, and a trace of other metals. Ores are largely mixed with iron pyrites, and pyrrhotite which appears to carry nickel. Composition of Sudbury ores.

John Babcock—I discovered copper with nickel on lot 10 in the 5th concession of Denison. I think it carries gold too. Most of the work was done by myself and McCormack, whom I had to get to take it up. The vein runs north-east and south-west; the country rock is hornblende and a kind of micaceous slate. I have but a very common knowledge of rocks. In Waters I discovered what I think is copper and nickel, but it has not been assayed as yet; I have not taken up the lot. In Snider I found two deposits of nickel and copper close to each other, on lots 3 and 4 in the 1st concession. Those lots have been taken up and we have done some exploratory work. There are two veins, both about 10 feet wide, their course being north-east and south-west. In Fairbank I found pyrites with little specks of galena. I don't think it is rich, but it might pay if a man were able to work it. Ores in Denison, Waters, Snider, and Fairbank.

Robert McCormack—I live at Sudbury and have been engaged for the last two years prospecting in this district from Snider to Denison. I have a copper location on lot 10 in the 5th of Denison; it is something like the Krean location, of which I think it is a continuation. There is copper on lot 4 of the 1st of Snider; it is of the same kind but not so large as the deposit on the Krean location. Copper occurs in the green rock. In Snider it is a kind of green rock on one side and grey upon the other. Locations in Denison and Snider.

George Shaw—In the township of Graham, on lot 6 in the 3rd concession, we find some very good lodes that the mining engineer says in his report form a continuation of the Vermilion. We are about stocking that for $100,000. On 5 in the 3rd we have alluvial gold. On 12 in the 5th, which we also hold, there is copper, an assay of which by Mr. Heys of Toronto shows 27 per cent. copper and $96.40 of gold per ton. The vein I understand is five feet wide. It is supposed to be a continuation of the McConnell lode, and goes across this location into the next. There is very little doing because each man is waiting for his neighbor to develop, and then hopes to make something out of his own. Locations in Graham.

D. W. Butterfield—I think from the indications, as far as we have gone, that copper exists in paying quantities at the Vermilion location. Our ore runs 25 to 30 per cent. copper, besides other metals. I have been told it contains nickel and platinum, or other metal of the platinum group. As to the copper on the hill, I cannot yet say whether it is a vein or not. I think, however, there is a large body of ore there, and I am satisfied with the development so far. I think as we get deeper down we will get more water, as the rock is not as close grained as at the gold vein. I do not expect we will have any trouble till we get down 100 feet, and then I think we can handle it with a pump. I do not think there will be any serious difficulty. In our mine here we have the copper in different forms—blue, grey and yellow copper, and also some native copper. There is some iron pyrites with the copper, some gold, some quartz and some arsenical pyrites I think, quartzite that carries gold and a small amount of silver mixed up with the vein matter, hornblende, platinum and nickel. No copper ore has been shipped as yet, and it is not determined where we will send it for reduction. The Vermilion mining works.

Joseph Riopelle—I am interested in about 1,200 acres of mining property in the township of Denison; our lots are in ranges 4 and 5. The owners of the property are Tough, McDonald and myself. We discovered minerals on the property in 1886 and 1887; we discovered mineral on every lot we purchased, the principal minerals being copper and nickel. We discovered gold on lot 9 in the 5th. The copper shows generally on the surface and is in veins. We have openings on all the lots, but have not sunk a shaft to any depth. We found some copper associated with and some without nickel. The only gold was that on lot 9, and I cannot say that was a vein; it was only a little native gold picked up when we were opening for copper. I place no value upon the gold at all. I have visited the copper regions of lake Superior, and I believe this to be the best copper section in the world. We have had some of the copper ores analysed by Mr. Donald of Copper and nickel locations in Denison.

Montreal ; it was an analysis of the lot we disposed of to a copper company since, and showed 34 per cent. That was in the township of Snider. The veins vary very much ; in some places we can hardly call them veins. We found ore going right across the township from north to south and cropping up. Wherever the vein cropped up we purchased as soon as we had developed enough to show that we were right. I do not know that there is a vein as the word is generally used ; it usually occurs as an overflow, sometimes showing pretty well on top. We are perfectly satisfied with the appearance of the copper and hardly deem it necessary to have any analysis.

Copper in Denison, Snider and Graham.

Henry Ranger—I have discovered copper on lot 12 in the 4th concession of Denison, on lots 9 and 11 in the 5th, on 8 in the 5th, on 8 in the 4th, and on 1 and 6 in the 5th. In Snider, on 12 in the 6th, I found copper. In Graham I discovered iron pyrites on 12 in the 3rd and on 12 in the 4th I found a quartz vein containing copper pyrites and galena.

Copper in Drury.

James Miller—The copper in the township of Drury is a mountain and extends about two or three thousand feet. About a mile further to the north-west it crops out again ; there is any amount of copper there. It appears to be decomposed as far as can be seen. The rock is diorite.

Copper and galena at Straight lake.

Edward Moore—I am a lumber merchant and am interested in mining properties at Straight lake, west of the township of Moncrief and 46 miles west of Sudbury. Copper was first discovered there a year ago last fall, and about two or three weeks ago galena was discovered. I cannot say whether the galena occurs near the copper, but it cannot be a mile away. I am speaking from what my brother told me.

GOLD.

Gold regions.

Of the localities in which gold has been found in Ontario, the Commission visited gold carrying veins in the Madoc or Marmora, Denison and Lake-of-the-Woods districts. Evidence was obtained in addition to the above in relation to the Huronian mine in Moss township, west of Port Arthur, and to many veins in the region of Sault Ste. Marie which are said to carry gold in paying quantities. All these are in the Huronian formation, if the first mentioned can be so included.

Richardson gold mine.

The Richardson gold mine is situated in the township of Madoc, in the county of Hastings, near the line of the Ontario Central railway. No work is now going on, but recently some parties have been exploring the old workings and opening new ground. Very promising looking rock had been taken out and was lying on the dump. The vein stuff consists of quartz with some iron pyrites ; dolomite and calcspar also occur in patches, and form a considerable part of the excavated matter. Talcose schist appears to form one side, and strikes with the greenstone and gneissoid rocks in an easterly and westerly direction, the dip being at some places 70°. The vein is not visible at the surface. A very interesting account by Mr. Vennor of the discovery of gold at this place is given in the Geological Survey report of 1869, together with a great many analyses and tests of ores in this district. Fig 10. is a section of that country drawn by Mr. Vennor :

FIG. 10.—♂ *Indications of iron. e. Crystalline limestone with graphite, syenite and gneiss. i. Diorite rock with iron ores. t. Calc schists, mica schists and conglomerate ; limestones and dolomites with gold.*

Canada Consolidated gold mining company.

The property of the Canada Consolidated gold mining company at Deloro, in the township of Marmora, was visited by the Commission, but the mine is now idle and full of water. Some extracts taken from a paper by

R. P. Rothwell, editor of the New York Engineering and Mining Journal, read before the American Institute of Mining Engineers, may be given as descriptive of it:

Description of the property.

About thirty miles north of the city of Belleville, in the township of Marmora, Ontario, there is found a belt of gold-bearing quartz veins which present geological, mineralogical and economic features of great interest to the profession. The district in which these veins are found is characterised as a rolling country, with low rounded hills of syenitic granite, overlain on the flanks of the hills by Silurian limestone which lies in nearly horizontal beds, and in some places is so fine in texture as to afford lithographic stone of a fair quality. The gold-bearing veins run north and south through this belt of syenitic granite and are quartz-filled, true fissures, with micaceous or talcoid slates forming the walls of and horses in the veins. This talcose slaty rock is evidently the product of the chemical decomposition of the syenite along the fissures, the quartz being segregated from the country rock into the veins, and the hornblende of the syenite furnishing the magnesia of the talcoid slates. The veins, besides quartz, contain also as gangue crystallised calcspar and occasionally crystallised black mica. The ore scattered through this gangue, in heavy bands in some places and in detached, well formed crystals at other points, is an arsenical sulphuret of iron (mispickel) having a composition of about 55 per cent. of iron and 25 per cent of arsenic, and perhaps 20 per cent. of sulphur. This mispickel contains the greater part of the gold for which the mines are worked, but free gold is also found scattered through the quartz in small leaves and grains, and it is also found showing freely at times in the mispickel itself . . . Some four or five parallel veins have been proved to exist in a belt of 500 or 600 feet in width, running through the property of this company for a length of over three-quarters of a mile, while the main vein has been opened on adjoining properties, making a total proved length of this great fissure of about three miles on the vein, a fact which, next to actual sinking, may be considered the best proof of the continuance in depth of the veins. . . . They have shown this vein to have a thickness exceeding 20 feet in many places, and averaging probably 8 or 10 feet, while the middle and west veins, though smaller, have still apparently a thickness of 3 feet and upwards.

Average of 108 samples, 515 tons Gatling ore, assayed by A. Thies, $13.37 gold per ton.
Check assays by Prof. Richards of Boston, and Gifford of New York, $14.75.
Average value Gatling ore, east vein, $14.06 per ton.
Average samples, aggregating 63 tons, Tuttle shaft, east vein, $24.88.
Average samples, aggregating 12 tons, middle vein, $30.82.

Some of the washed ore was treated by chlorination under pressure (Mears' process) and practically nearly the full fire assay was obtained. Even including the loss in flue dust in roasting in the revolving hearth, an ore which assayed less than $14 per ton yielded net in the bullion 91 per cent. of the fire assay, so that it is thought that by care in roasting from 93 to 95 per cent. of the gold in the concentrates can be regularly obtained.

Chlorination works erected.

The accompanying sections of the Gatling mines (Fig. 11) are by Mr. R. H. Stretch, M.E. Since Mr. Rothwell's report large chlorination works, with chambers for collecting the arsenic, have been erected. It is stated that they could put forty tons per day through a Blake crusher. The ore was next broken by Cornish rolls, concentrated, and the concentrates ground by mill-stones, after which the material was roasted and the arsenic caught in chambers. The roasted concentrates were put into a barrel with free chlorine gas and revolved then washed and the gold deposited from the solution. The process is described

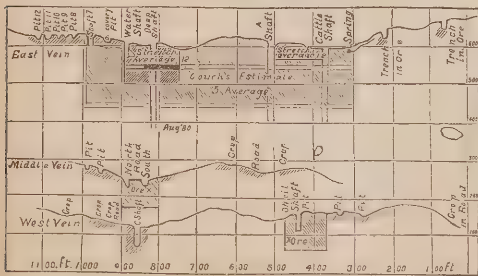


Fig. 11.

more fully by Charles W. Wilmot in his report in the Geological Survey publication for 1882-3-4, Part 4. The tailings from this process are now being run over a table containing mercury in the riffles and oscillating 90 per minute. Sodium amalgam and nitrate of mercury are put in with the mercury, and also a few grains of copper filings after the nitrate of mercury is added. The filings keep the mercury from flowering. It is found that either by the action of chlorine or the ordinary action of the atmosphere—for in the case of all these veins free gold is found for a certain depth down—the gold has been liberated, and by the process just described they get from $3.50 to $6 per ton from the refuse tailings. The local opinion is that the concentrates have not been ground fine enough to let the chlorine have full action.

Denison township.

The only gold-bearing quartz veins visited by the Commission in Denison township were those at the Vermilion mine and on the Vermilion river. At the former place the vein runs east and west in a close grained quartzose dioritic rock, with a small quantity of iron pyrites scattered through the quartz. The vein matter appears intimately mixed with the wall rock in stringers, without having clearly defined walls. The gold occurs apparently indifferently in the quartz and wall rock, specimens of the diorite being found interlaced with the gold wire. It is found in the quartz in the usual manner, imbedded in branch-like pieces where visible, but in the wall rock it seems generally in wire formation. The gold also is found in the iron pyrites in places, and where visible it appears in specks. The vein is nearly perpendicular, and a shaft has been sunk upon it about 40 feet in depth, showing a vein varying from two to four feet in width.

Vermilion mine.

Vermilion River location.

The vein on the Vermilion river is on lot 1, 4th con. of Denison. It strikes north 60° east, and seems to be about perpendicular. It is a strong vein, 12 feet wide, consisting of white quartz with reddish tints in places. It carries a little iron pyrites, copper pyrites and plumbago, and is reported to have a paying quantity of gold. This vein occurs in a grey dioritic rock, which forms both walls.

Lake-of-the-Woods district.

As yet it may be said that no mining has been carried on in Lake-of-the-Woods district other than of a preliminary and development character, and as all the shafts are filled with water it is impossible to say what they have proved. It may be said, however, that the prospects of paying gold mines in this district are singularly good, but great care will have to be taken owing to the broken and uncertain character of many of the veins or quartz infiltrations and the refractory character of the ore. As a rule the quartz is intimately mixed and connected with talcose schist, which seems to occur chiefly as a lining to the vein and which may be the result of decomposition of the country rock. Much of the quartz also is iron-stained, but sometimes it is quite white and does not appear to carry any mineral. Other varieties of quartz again are sugary, and sometimes with a pinkish tint. Where the quartz carries mineral it is chiefly iron or copper pyrites, and in places free gold is visible. It is stated that the free gold is only found near the surface, and that in depth most of the veins carry arsenical pyrites or mispickel, which makes it difficult to treat. Very rich specimens containing free gold

were shown to the Commission, which are stated to have been taken from this region. As no mining is being carried on, we shall give a few brief notes of some veins visited, and the evidence must be looked to for further information regarding the district.

Sultana property.

A number of veins are being opened at the Sultana property, which in many places appear to be quartz segregations in local joints or cracks in the strata, which run into the country rock at different angles and disappear, and many of which carry minerals. The uncertain character of many veins is a common feature of this district, so far as we have seen. For example, in four out of some half-dozen places where quartz is exposed—

(1) A quartz vein or "splash" strikes in a north 20° west direction and dips at a steep angle to the east; it is two to three feet wide and intimately mixed with talcose schist. It is said to carry gold, but cannot be traced along the surface.

(2) A quartz vein occurs in a grey porphyritic syenite with large crystals of felspar and some quartz and pyroxene. It seems to be a local impregnation of quartz some three feet across in places.

(3) Ophir Jack opening is on a three foot quartz vein. It runs north 30° east with the shales, underlies to the west, and is visible for some distance up the side of a hill. It has the appearance of a true vein, and therefore constant.

(4) Another opening striking north 80° west is three feet across. It underlies to the north and cannot be traced on the surface. There are reported to be a large number of quartz veins carrying gold on this property which we did not visit.

Gold Hill property.

On the Gold Hill property a strong reef of quartz and talcose schists 33 feet wide strikes north-west and south-east and dips south-west. A shaft has been sunk upon it, but it is filled with water. It is said to be solid quartz below. On the surface it can be traced some distance and is found on the other side of a small lake. Other veins are reported to exist on this property and to be rich in gold, as is set forth in the evidence.

Winnipeg Consolidated.

The Winnipeg Consolidated property shows a vein about two feet wide at the surface, striking north-west and south-east through diorite, and intimately connected with a talcose schist as lining to the vein. It is a close-grained sugary quartz carrying mineral, and is said to widen below to four feet. A stamp mill was at work for some time on this property, concerning which the evidence gives infornation.

North shore of lake Huron.

North of Little Current the Huronian formation comes in on the north end of Lacloche island, replacing the Silurian. Several islands between Lacloche and the main shore on which we landed are composed of diorite, quartzite, chloritic and hornblendic schist, sometimes considerably altered. The strike is nearly east and west and the dip about 80° north. As a general thing there are quartz veins, stringers and infiltrations of quartz in joints in these rocks on the islands, and especially in the schists, some of which carry minerals. At Edgeward island iron and copper pyrites and mispickel occur in the infiltrated quartz, and the asays are also said to have given gold and silver. The rocks of this island are compact chloritic schists,

highly altered and running into a close grained and hard greenstone or greatly altered schist at the north end. Quartzite also occurs on the island.

At two places pointed out on timber berth 110, on the mainland, mineral is found in quartz veins or stringers. In one of these it occurs in conjunction with chloritic schist and quartzite, and in the other, a mile inland, in trap. The first contains galena, and is said to carry gold. In both cases the quartz stringers run with the rocks easterly and westerly. The prevailing rock here is a schistose quartzite.

The Feigle and Gladstone mines in Marmora.

D. E. K. Stewart—I am a solicitor living at Belleville. I have been interested in mineral lands since 1866, but did not attempt regular gold mining until 1878. In the latter part of that year I leased the Feigle mine in Malone; afterwards I purchased the Gladstone in the same vicinity. The Feigle is, I think, on 18 in the 11th of Marmora, and the Gladstone on 17. I think I took about $20,000 in gold from there; the gold was sent to the mint. The vein is quartz in syenite, carries considerable iron pyrites and is very irregular in width, varying from one to fourteen feet. It has been traced some 1,200 or 1,400 feet, and a great number of openings have been made upon it. There are two shafts, one of 50 feet and the other 80 feet. The rock on both sides is syenite, the vein matter chiefly quartz, with mispickel and some country rock through it; the country rock is granite. I simply treated the ore for the free gold. We did not consider the sulphurets rich. I cannot say how much free gold there was to the ton. Some of it was very rich and some very poor. I think we saved pretty much all the free gold. Analyses have been made of the tailings, and they carry very little. I think the quantity put through the mill gave from $3 to $50 a ton. The mine had been worked for years before I got it, and I worked it about 13 or 14 months. I treated a quantity of ore from the Gatling or Consolidated at Malone, and it went about $14 to the ton. I believe it was just the average ore. It was crushed, concentrated and amalgamated. The rock was sent to us to make a test of it, and it was admitted that we saved 80 per cent of the gold the rock contained. They afterwards put in the chlorination process to look after the other 20 per cent., and that, I think, was the cause of their failure. Fourteen dollars a ton should pay very well. I think the rock at the Gatling would average about $14. The vein is from 8 to 12 or 14 feet wide, and carries a large amount of mispickel. We put through about 70 or 80 tons of it. Mispickel ore can be treated satisfactorily by roasting and amalgamating, and by working it that way I think the mine could be made to pay handsomely. This would apply to all these arsenical sulphuret ores from the mines in that vicinity. I think veins of this kind occur for a distance of about two or three miles. As a rule gold-bearing quartz varies in richness, but in this section the veins are uniformly rich. I think they run about $14 a ton as the ore comes out of the mines; it is worth that to mill. When it can be made to yield $14 per ton by roasting and amalgamating I think that trying to save more by the chlorination process would only entail loss. The Richardson mine is a quartz vein carrying copper sulphuret; it is quite rich. At first the Richardson carried a great deal of gold, and some of the finest specimens ever got in the world were from that mine. I would not call the Richardson ore mispickel; it carries no white arsenical pyrites. There is any quantity of that in the Williams, Gatling and Hawk-eye. The only mine that can be said to have been really developed is the Consolidated, and that is down 200 feet. Below the Consolidated, on lot 5 in the 9th of Marmora, is a vein that has been worked a little; one on 4 in the 8th; one on 5 in the 8th; then I don't think the vein is opened till we reach the Consolidated, where there are four or five shafts. After that there is the Gatling property, then the Hawk-eye, and then I don't know of any more till you come to Malone, four miles further up the river. At Malone there is the Feigle, the Gladstone and Cameron; across the river is a cross vein of nearly solid sulphurets. Then north again and east there is the Richardson, and one on lot 28 in the 5th of Madoc. At the Richardson gold is found in about every kind of rock. I have washed gold out of earth about half a mile south of the Gladstone, and got color in the pan; that would be on 17 in the 10th. The last mine north that I know of is the Craig, in Tudor. The Richardson vein runs east and west and dips to the north; the cross vein at Malone runs the same way. The mispickel veins run north and south. They are generally in syenite. I never saw a vein that could be properly called a contact vein. The Gladstone was chiefly quartz and iron pyrites, scarcely any copper pyrites; on one

The Gatling mine.

Treating mispickel ore.

Richardson mine.

The Consolidated mine.

Various locations.

Character of the veins.

occasion only I found a piece of native copper in that vein. I found a quantity of mispickel in one shaft of the Gladstone. I was working in too many places, and had no capital to speak of; if I had sufficient capital I think I could make the Gladstone pay handsomely. The vein was irregular. I think there are a number of properties that would pay if properly worked, and if the owners would put their property in against the capital to develop it. One great trouble has been that owners have been holding undeveloped properties at too high a figure. However, that evil has to a certain extent cured itself, and at present owners are more reasonable. I do not consider that mispickel is a very hard ore to treat if the proper system is adopted. A considerable quantity of gold was taken out by Osler, some $30,000 or $40,000, I think. He had a 20-stamp mill, but I do not know that he worked all the stamps, I think he only worked five. There is a gold mine at Kaladar, and I have it on good authority that it yielded $7.50 to the ton. I have seen some of the rock from there showing good specimens of free gold.

Working without capital.

Kaladar.

John Stewart—The Richardson-hill is the property adjoining the old Richardson property on the west. I shipped ore from there, and was superintending around at different times. On the foot wall it was syenite; I cannot say what it was upon the other. The vein matter was micaceous, and there was some diorite. It carried pyrites, gold, copper pyrites, magnetic iron and a little hematite, a good deal of dolomite and spar, and a great deal of lime matter associated with the ore—a mixture of everything.

Richardson-hill location.

Charles Taylor.—We are at present taking the gold out of the tailings of the Consolidated mine by amalgamation. Our process is a simple one and is not patented; it simply consists in using a sodium amalgam. When our mercury flowers we use a copper amalgam. I do not think we get all the gold. In every ton we put through I think we leave $25 or $30; if assayed it will show that. By the first process the company adopted I do not think they got more than $7 or $8 a ton of concentrates, though it assayed from $60 to $70 to the ton. The first process was to pass it through Cornish rolls, then it went through a large screen, then through jigs, then it was put in a revolving cylinder and fired, the arsenic being condensed in a large chamber. The average gold in the ore was $15 to the ton, and in the concentrates $60 to $80, but it is seldom that more than one-half the amount of the assay is got. We take about $4.50 a ton out of the tailings; we put through about eight tons a day, and with two men we take out from $100 to $150 a week. We began working about the latter part of June, but water was scarce; now water is plenty, but the weather is getting too cold. This ore was treated by the chlorination process, but the article treated was not half burned, and all the gold was got out of the small part that was calcined. The dust on the beams of the wall assays $20 to the ton. The oxide of iron, if outside the gold, prevents the mercury from touching it, but by using caustic soda the oxide of iron is cut from the surface. In a building 40 feet square I can do twice as much as they can do with all their works at Deloro, which cover half an acre. My pulveriser can be placed in position without foundation or anything of that kind. After crushing the ore I would burn it and take out the arsenic, and then it would be in a state to take out the gold by my process. If you were to stamp as fine as my pulveriser does you would not be able to do more than a ton a day, while I can pulverise from 8 to 10 tons a day. This machine occupies but a small space, and I am prepared to enter into a contract to crush from 8 to 12 tons a day, and put it through 60 mesh. These refractory ores should be calcined in all cases. I have not as yet treated any arsenical ore here that was not treated before, but we treated arsenical ore in Nova Scotia. Except my process, I do not know of any by which it can be successfully treated; no one has treated it with caustic soda but myself. The proportion of caustic soda used is about two pounds to the ton of water. We keep the water up to blood heat and oxidise the mercury with acids; we also use a little muriatic acid and a little sulphur sometimes. The caustic soda will clear grease from the mercury.

The Consolidated mine.

Extracting ore from tailings.

Process of treatment.

E. B. Fralick—I have been interested in mining affairs a considerable time. In 1866 I was interested in a gold property adjoining the Richardson mine, to the south and also to the west. Openings were made and we prospected, but not with a great deal of success. Our property was considered very valuable—it was known as the Fox property—and subsequently there was a great chancery suit about it. A shaft was sunk on the vein and we found colors of gold, but not in paying quantities. On the Moira property to the south there was a vein like a spur running from the main Richardson vein. The rock was chiefly dolomite. Those were the only gold properties I was interested in.

The Fox location in Madoc.

Gold location in Kaladar.

Deroche and Burrows—We have a mine situated on lot 25 in the 6th concession of the township of Kaladar, in Lennox and Addington, and about 6 miles from the Kaladar station on the Ontario and Quebec railway. It was discovered in 1881. Many assays were made showing it to be good "pay rock." In 1887 the owners sent about three tons of the ore to the gold mill at Malone, where the free gold alone yielded a bar valued at $65. The sulphurets, which are known to be rich in gold, were not treated owing to lack of proper apparatus. Last year two shafts, each 30 feet, were sunk exposing the vein and showing it to be a true fissure vein. The matrix is quartz. One of the wall rocks is a chloritic slate; the other is a very hard conglomerate, which appears to have been tilted. The general direction of the vein is north-east and south-west. It varies in width from five to twelve feet, and can be traced on the adjoining lots. This property is well situated, there is an abundance of timber, and excellent water power on the Scootamatta river which flows through the adjacent lot.

Gold in Sherbrooke township.

Wm. Hicks—I am interested in a gold property on the north-east half of 12 in the 2nd concession of Sherbrooke. It was discovered in 1880 and I bought it in 1881. I cannot tell if it occurs in a vein. I spent about $120 on the property and it has remained that way since. The analysis showed $25.10 silver and $128.32 gold. I was offered $30,000, but I thought I should have got half a million. The vein matter was very hard, a kind of reddish green rock. To satisfy myself I got three more analyses—one of which, made at Denver, gave from $60 to $80. There is a great deal of pyrites in quartz, and wherever we get pyrites there is sure to be some free gold. I should have said the three analyses I got made were $60, $80 and $128. The location is about 16 miles from Perth.

Gold on Lake Wahnapitae.

Charles Dobson—On the north shore of lake Wahnapitae there is a vein 46 inches in width that carries gold. It can be traced by the outcroppings for about 2,000 feet, and runs north 45° east. It is 300 or 400 feet back in the woods from the edge of the lake. The hanging wall contains mispickel, that part being about three feet wide; it lies under the granite. On the foot wall there is gneiss. The mispickel averages $860 to the ton, and the quartz vein matter $40 to the ton. I saw gold on another location that Mr. Sheppard is interested in on the same lake. It looked very well. I saw a good deal of free gold, and from present indications I would imagine that it will be rich. The wall rock appears to be especially rich in gold. In the township of May, on the Algoma branch, there are quartz veins which vary in width from 6 inches to 4 feet 6 inches, traceable for two miles. They run west 20° north. The aggregate width of the veins, which run parallel, is 41 feet; there are six or seven veins I suppose. Assays made at Chicago showed from $120 to $134 to the ton. Assays by Professor Heys, of Toronto, showed within 4 dwt. of the same.

Gold in May township.

Gold in Graham.

George Shaw—On lot 9 in the 1st concession of Graham we found gold that went as high as $1,100 a ton; there was a little free gold in that. It appeared to be a good straight vein.

Gold in schist and diorite.

James Stobie—Schist seems to be intimately connected with gold; it seems to be the casing. I have seen gold in the diorite near shaft No. 1 of the Vermilion mine. Gold has also been found on lot 9 in the 5th of Denison.

The Vermilion gold.

Francis Sperry—Gold as far as I know has been restricted to the Vermilion mine. I have made numerous assays, but cannot find as much gold as other chemists.

Charles Kettyle—I have a gold claim in the township of Waters, on lots 5 and 6 in the 6th concession. The vein can be traced 200 yards, and is from 20 to 28 inches wide. The first assay from the surface showed $28 to the ton, the next at 2 feet down $32, and at 6 feet down $76. These were not picked specimens. A large part of the gold was in sulphurets. The rock is hornblende slate on both sides.

Gold in Waters township.

P. C. Campbell—I am interested in a location in the township of Waters that yields gold, silver and galena. There are two veins upon it. We sank six feet on the galena vein and three feet on the quartz vein. An assay from the surface showed 42 oz. of silver to the ton, and 1.2 oz. gold. The location was discovered by C. J. Kettyle. No work has been done upon it more than putting in a few shots. Openings have been made about six feet in the galena vein and about three feet in the quartz vein.

Gold vein in Snider.

R. McCormack—In Snider, on lot 3 in the 2nd concession, there is a quartz vein carrying $23.50 gold and $2.50 silver; also some copper, but I do not know how much. The vein is from 2 to 2½ feet wide.

Henry Ranger—I was the first to discover gold in this part of the country; it was on the 3rd of September, 1887, on lot 6 in the 4th of Denison. I found free gold in two veins in Denison; it was in quartz, in the country rock, the same as at Vermilion mine. I really found free gold in four places on lot 6; in one place there was no quartz, just a splash of free gold upon the common country rock.

Discovery of gold in Denison township.

B. Charlton—I am president of the Vermilion Gold Mining company, which has been organised about a year. The capital stock is $240,000, of which 60 per cent. is paid up. About a quarter of the stock is Canadian, and three-quarters American. Our property is in the township of Denison, in the district of Algoma; we have nine lots of about 320 acres each, altogether between 2,700 and 2,800 acres. We have carried on active operations since the first of May, but have now stopped work for the winter. We have only done prospecting work as yet, and are not deep enough to protect the men working in the winter. We have one shaft of 40 feet, another of 30 feet, and another of about 20 feet; the shafts are all within a radius of 500 or 600 yards. We have been looking principally for gold, but have got a good deal of platinum, copper and nickel. The nickel is combined with the copper, but I cannot tell you in what percentage. It would be impossible to give the average, it varies so much. One shaft is all gold and no copper; the next shaft shows a large quantity of copper and some gold, and considerable platinum. In the vein that contains nothing but gold we have not gone far enough to determine whether it is a clearly defined vein. It is a quartz vein and appears to be well defined. So far we have been exploring, and not working with a view of getting a large return. We have got a good deal of gold already, which we have sent to the mint and disposed of—several thousand dollars worth of gold. The machinery we have there is simply for exploring, a small prospecting three-stamp mill. Besides the veins we are working, there are other very rich indications. I cannot tell you how much we have spent so far in the development, nor the amount of gold to the ton of vein matter. The vein where the copper is found is widening out very much of late; it is very irregular, and therefore it is a very difficult matter to tell the actual width. The shaft in the gold vein is about 40 feet down. It has been enlarged since the members of the Commission were there, and I think is now 10 by 6 feet. Free gold is found at the bottom of the shaft. We got out very rich specimens at the very last. In shaft No. 1 we found arsenic, but only one assay showed it. The platinum was got in this shaft. The property can hardly be said to have been prospected at all, still some 15 or 20 veins have been discovered upon it.

Vermilion Gold company.

A. G. Duncan—My home is at St. Joseph's island, and I am vice-president of the Vermilion mining company. The company was organised last fall, and got its charter this spring. B. Charlton of Hamilton is president and John Oliver of Chicago is secretary. The capital stock is $240,000—55 cents on the dollar paid up and 24,000 shares issued. Americans hold the majority of the stock; they are Chicago capitalists.

Vermilion mining company.

D. W. Butterfield—My home is at Waukeegan, Ill. I have had six or seven years experience in gold mining and milling, particularly in the Black Hills district. I have held the position of superintendent of the Vermilion company since the 1st of April, 1888. My experience has been principally in connection with gold mining, and till I came here I never had anything to do with copper; my experience has been all along with free milling gold ores. I have not seen enough of this country to give an opinion as to the minerals it contains. What properties I have seen are not developed, but as far as I have seen the indications are very good as to gold existing in paying quantities. The gold-bearing vein at No. 2 shaft here strikes north-east and south-west. The width of that vein where we have worked it is from 12 to 30 inches; it is traceable on the surface for, I think, about 150 feet to the east, when it seemingly runs into the swamp. We traced it west of the shaft for some distance. The vein matter is quartz, carrying gold; there is some iron pyrites, and perhaps a little copper pyrites. I think it carries other metals, but what they are has not been determined yet. I think I have seen a little galena, but very little. Occasionally we find a little spar, but hardly enough to be worth mentioning. There is no resemblance between the veins here and in Dakota; the quartz there is mostly darker, being stained with iron and of a softer nature; it is not sharp white quartz such as is here. As far as we have gone we consider the vein encouraging for gold. The water does not trouble us to any extent; during the spring we had some water, but not enough to interfere with our working. In this district there is plenty of timber and water for working. The timber, of

Vermilion gold mine.

Minerals in the vein.

course, is not of the first quality; it will answer our purpose till we get into deep mining, when we will have to get green timber. As to the labor market here, wages are reasonable. There are 27 men on our pay roll now, and we have a light three-stamp prospecting mill. I think we will find the facilities for transport satisfactory; we are well situated for that, being only two and a half miles from the railway.

Labor and transport.

Thomas Frood—I have obtained samples of gold from five or six places between the township of May and east to Neelon, a distance of about sixty miles. The gold was in small quantities only, and the rock from which it was obtained was quartz and schist; the best I got was from a little bit of schist in the township of Neelon. If it could be got of the same quality as the specimen it would go about $8,000 to the ton.

Gold samples from various localities

William Ward—The locations 1P and 2P, on the north shore of lake Huron, are on the main land and contain about 330 acres. I was there last summer and we discovered two veins of quartz. An assay from one showed 24 dwt. of gold to the ton, and from the other 12 dwt. I feel confident the veins run through both locations.

on the north shore of lake Huron.

James Proctor—I am interested in Flat Point island, 1P, 2P, 3P and 4P. I have never been upon the properties, but I have seen specimens. The averages of the tests we have had made ran from $10 to nearly $6,000 a ton. Some of the veins have 30 per cent. copper.

Flat Point island.

J. D. Dewar—I reside in the city of Toronto and am a metallurgist. I have made tests for the Pine Portage people, for Sudbury people, and for people all around. I have assayed several specimens for Dobie & Gordon, of the Pine Portage. The vein matter of that mine is white quartz, in places carrying nothing but free gold: there are many veins, some of which carry silver, lead and gold; others silver and sulphur. I was never on the ground, but have had some of their stuff. I treat specimens by a process which brings the gold to the surface, and receive a great many specimens to treat in that way. I have visited some locations on the north shore of lake Huron. There is one location on Flat Point island, another location called 1P, and another called 2P. Flat Point island is north-east of Lacloche island, close to the main land, and is about seven acres in extent. Some development work has been done upon it and good samples obtained. The whole island is a body of veins from an inch to ten inches wide on top, but they get a little wider as we go down. We only examined one corner of the island, on the lake side. There was one shaft down ten or twelve feet. Another opening five or six feet deep was made on the west side of the island, and some very rich gold was found. There is really no division between the veins; they are stringers running all over. A vein of about two feet runs from $100 to $300 to the ton. When we get down a little way there are vughs full of little nodules which carry heavy free gold. These vughs occur frequently in veins over a foot wide. If we do not find the nodules we find yellow or brown dust containing gold. The gold occurs in the rock as well as in the nodules. There are about a dozen openings made on the island, but all are not equally rich. In addition to the gold there is a vein of copper on the island, from three to six inches wide, on which is an opening of about ten feet. The country rock is all of a crystalline limestone formation and is easy to work. The whole island is really a vein, and every bit of the rock that we have assayed shows gold. There is nothing one can really call wall rock. About one hundred yards from the shore on the mainland is a vein four or five feet wide which contains gold. There is a white quartz vein with specular iron carrying $24 a ton of gold on 1P. The vein on 2P is two or three feet wide, but none of it has been analysed.

Lake-of-the-Woods gold specimens.

Flat Point island location.

E. B. Borron—The first to make known the existence of gold on the north shore of lake Superior was, I believe, Professor Chapman of Toronto, upwards of twenty years ago. If I remember correctly its presence was detected by him in the ore of a vein at Black bay, where it was associated with galena, copper ore and some silver. Shortly afterwards gold was found a little beyond the height of land west of lake Superior, at Jackfish lake. As far back as 1660 it was reported by the Jesuit missionaries to have been found on St. Joseph's island. In 1852-53 one of the men employed by the late Mr. Molesworth in making a survey of the island stated that he had found gold. At the request of the late Sir Hugh Allan, who heard of it, I spent two days looking for it, and it is needless to say I did not find it. There may have been some foundation for the rumor; the gold may have been found in boulders transported from some point on the north shore. Gold had been found on the Chaudiere river, Quebec, a few years before; a few years later it was

Discovery of gold on lake Superior.

St. Joseph's island.

discovered in Nova Scotia, and subsequently it was found at Madoc, in Hastings county, on lake Superior, Lake-of-the-Woods, and still more recently on the north shore of lake Huron. It would thus appear as if there was an almost uninterrupted belt of gold-bearing rocks extending entirely across the province of Ontario, if not from the Atlantic to the Pacific ocean. Were I otherwise competent, so little has been done in the way of exploring and development that I am not in a position to give an opinion as to the importance of these deposits to the province. Gold is found in almost all parts of the world, but in too small quantities to be worked profitably. In the neighborhood of Leadhills and Wanlockhead, Scotland, it has been known for over three hundred years that gold exists in every little stream, but not in paying quantities. As recently as 1860 a few of the old lead miners would go occasionally and wash gold, being induced to do so by the fact that the neighboring gentry would give them from three to six times its commercial value because it was Scottish gold. From a commercial point of view the payment of such prices might be described as idiotic. Yet there are not a few of our cautious and intelligent fellow citizens who have paid as much for every grain of Canadian gold obtained from the mining locations and mines in which they have been induced to invest. As elsewhere, so in Ontario, the poor veins, whether of copper, silver or gold, outnumber those which can be worked profitably. There can hardly be any doubt but that in a gold-bearing district of such extent there are some good veins. But till there has been a demonstration of that fact by at least one good paying mine, I do not anticipate that our deposits of gold will attract much attention outside the province.

Various discoveries showing an extensive gold belt, but poor veins preponderate.

Ambrose Cyrette—On the Heron bay property on Pic river, 180 miles from Port Arthur, a shaft was sunk 55 feet. There is gold there, and an assay showed $5,332 to the ton, but I suppose that was a picked specimen. The vein is quartz, the country rock blue slate; the vein proper is about two feet, and there is about 8 feet of vein matter. The walls are clearly defined, and there is both gold and silver. The property consists of 3,500 acres, but is not being worked now as the owners quarrelled over it. I have an interest in the property, but never got anything out of it.

Heron Bay location.

Peter McKellar—For gold there are the Huronian mine and a few locations at Lake-of-the-Woods. At the Huronian about 600 or 700 tons of vein matter was put through the mill, slate and quartz; it turned out $600 of bullion, and about 40 tons of concentrate worth about $150 a ton. I sent 4½ tons and was only allowed $100 a ton for the concentrate. At the rate they allowed me it would have been about $7 a ton for the ore, but according to the analysis of Hoffman it should have been $10 to the ton. If the mine were properly opened and worked it could be raised to $15 a ton, but I think to work it at $10 or $12 a ton would be the most profitable way and would give the best return for the capital invested. The vein we worked was about 6 feet and very regular. There are other beds alongside that carry as high as $133 to the ton of concentrates; they are very large and would keep immense mills going if they carried that right along, but only a few tests have been made. I think the Huronian will pay well when a good road is built to it. There are other promising deposits there; in one place there is a 16 foot vein in which one can see a few nuggets, but it does not appear to continue like the Huronian. I examined the Winnipeg Consolidated in the Lake-of-the Woods; the vein was about three feet wide and they were down about 70 feet. The quartz proper of the vein was 6 or 8 inches on the foot wall, and 4 or 5 inches on the hanging wall, the centre part being schist. I did not test it and cannot say what it assayed; they claimed it was high. Near Jackfish bay in the Huronian slates there is a vein carrying free gold. It is three miles back and carries gold as high as $27 to the ton in selected samples; it is a strong fissure vein. The other vein there is in red granite. Gold has been found near Poplar river not far from Nipigon bay: it was in a silicious bed of rock, but it did not look to be a regular vein. The gold veins are more in the Huronian formation, but one of them is in the syenite; the others are all in the slate. The slates are largely chloritic, the vein being quartz. There is very little free milling gold; it is generally combined with sulphurets. In the Huronian mine there is considerable free gold in places, but it is not more than one-sixth; the rest is sulphurets. The veins generally occur in chloritic and talcose slates. As a rule gold veins run with the formation.

Huronian gold mine.

Winnipeg Consolidated.

Jackfish bay.

Poplar river.

Gold chiefly in sulphurets.

A. J. Cattanach—A railway to the west of Thunder bay would open up the Shebandowan country, which is a very important country as far as gold is concerned. I understand from good judges, practical as well as scientific, that the rock there is

The Shebandowan country.

the true gold-bearing rock. I sold the property (160 acres) on which the Huronian mine is located for $50,000 cash for the owners and I understand the present owners, who are Canadians, have spent between $100,000 and $150,000 upon it. Everything is ready to go on with the work, but the means of communication are so bad that it practically prevents work at all. It costs about $70 a ton to get material in, and that renders the expense so high that nothing but very high grade ore can stand it.

Character of Lake-of-the-Woods ores.

Arthur Harvey—The gold ores in the Lake-of-the-Woods section are refractory, but not to the same extent as the ores of Marmora and Madoc. I have no knowledge of the character of the veins except from the experience gained at the Pine Portage. The ores there were free smelting on the surface, but down below they became more and more refractory. They contain arsenic, but not so much as at Madoc. My opinion is that the gold district will develop even to a greater extent than the silver district. I understand that fair veins of gold have been found as far east as Shebandowan. I have seen specimens of gold from north of Port Arthur, and I have knowledge of gold properties as far as Heron bay, lake Superior. I think the Lake-of-the-Woods is a better country to explore than almost any other part.

Lake-of-the-Woods veins.

Pine Portage location.

Treatment of the ore.

Area of the gold region.

Development work.

Arsenical ores.

J. F. Latimer—I am engaged in assaying and reside at present in Toronto. In about twenty of the veins around Lake-of-the-Woods I have found free gold by crushing the rock and washing it in the pan. Most of those veins were too narrow to work profitably. Perhaps four or five of them could be developed with a fair prospect. These would average from $20 to $40 or $50 a ton, but not all free gold. I do not know whether they would go deep. The deepest opened there that I know of is the Pine Portage; the vein is about 6 feet. They are down about 100 feet, and it carries gold from the surface to the bottom. Samples which I got myself that came from the bottom would go $2,000 or $3,000 to the ton. From the top the best went something over $1,300. These would be selected specimens of course. I think it would average all through $40 or $50 a ton. There is considerable free gold. A good deal of the ore is so refractory as to require special treatment, but I think it could be treated profitably. I do not think the proper methods have been tried. In the first place, the ore requires thorough roasting; a partial roasting will not do. I think the best process would be to concentrate, and then treat it by the furnace process; that would expel the sulphur, arsenic, antimony, etc. I have experimented with the furnace process and have got nearly as good results as I did by assay. The process is partly calcining and partly chemical. The gold region of the Lake-of-the-Woods extends over a large area of country. I have taken free gold from places over an area of 40 miles in length by nearly as much in width. I have seen specimens said to have been taken beyond that, 50 or 60 miles to the east, and some little distance further west. The principal developments are at the Winnipeg Consolidated, where they are down 115 feet, and the Pine Portage where they have reached 100 feet. In the Winnipeg Consolidated there is not much arsenic, but there is considerable sulphur. Gold there is generally found in a quartz vein with slate on both sides, or slate on one side and trap on the other. In the case of the Pine Portage there is a great deal of iron pyrites, and there may be some arsenic, but there is not much. The arsenic occurs in patches, but speaking in a general way there is not much of it. The Keewaydin location contains a good deal of arsenic mixed all through it; one can smell it on striking the rock with a pick. Most of the ores have not got arsenic, but they are refractory; they contain a great deal of sulphur and a little antimony and copper.

Lake-of-the-Woods region.

Gold-hill location.

John K. Wright—I am a resident of Rat Portage and have been for the past three years. I have had experience in mining for the precious metals in the western states and territories. I own, in company with D. B. Burdette of Belleville, eight locations on the Lake-of-the-Woods known as the Gold-hill mining property, and consisting of 906 acres. I have made careful surface prospecting upon it and have found two well defined fissure veins. We have seven openings, one a shaft 5 by 7 and 56 feet deep, another 5 by 7 and 33 feet deep, the others 5 by 7 and averaging about 10 feet deep—three upon the Ada G. vein and four upon the Combination. The Ada G. runs north of west and dips south about 45°, about 16 inches wide on the surface and 3 feet at 10 feet. The hanging wall is trap and the foot wall appears to be granite. The gangue consists of talcose slate and gossan matter next the walls, and it is auriferous from wall to wall, being equally distributed throughout. The Combination is a mile south of the Ada G. and parallel to it, occurs similarly to it, and dips at the surface about 30° south. It shows more coarse or free

gold at the surface than the Ada G., but the free disappears lower down and the gold is found in the form of sulphurets. At one point, a mile north of the pits, the vein opens to a much greater width. This is known as the Judge Mills location, and it has been tested to a depth of 33 feet without any closing of the walls. The Ada G. was prospected and surveyed in 1885, and the Combination lead in January, 1886, and all the development work was carried on during the summer of 1886. One shaft on the Combination is within a mile of Lake-of-the-Woods, and another one and three-quarter miles. Those on the Ada G. are about two miles from the lake. Work was discontinued owing to a disputed claim. The Combination vein has been traced from the neck of the peninsula north of Moore bay in a south-easterly direction by Cedar and Gold lakes to the contact with the granite, a distance of three miles. The Ada G. has been traced from an inlet in the south-east part of Big Stone bay, parallel with the Combination, north of Islet lake to Hollow lake on the contact. I think both veins run together on the contact, but a sufficient examination to determine this point has not yet been made. A large number of assays have been made, the lowest of which from the Ada G. yielded $52 a ton. The Combination yielded a little higher, and the average from both is about $65 a ton. A mill test of $2\frac{1}{2}$ tons made at London, Pittsburg, Chicago and Denver yielded $200 per ton, but this was from picked ore and cannot be considered as a reliable test of the veins. At the surface it appears as free gold, the vein rock being as I think partially decomposed by weather exposure. At a lower depth the gold is found as a sulphuret, and I think this is the fact below the line of permanent saturation. I consider the whole a free milling ore, and that the sulphides can be collected and treated economically. All veins that I have seen in this district have a general course of 10° north of west, but they vary on striking the line of contact. There are a great many cross veins, but I do not think they are at all valuable; they are feeders to the main veins pointing to the line of contact.

Contact veins.

Assays of the ore.

Course of the veins.

Alexander Matheson—I am chief trader of the Hudson Bay Co. at Rat Portage, and have resided here eight years. I have taken a general interest in mining affairs here, having purchased several properties from prospectors and held shares in the Winnipeg Consolidated and the Canada gold mining companies. The Winnipeg Consolidated was stocked for $1,000,000, but I do not know how much was subscribed. I acquired the property in 1881 and sold it to the company in 1883; it consisted of 69 acres in F 22 and 160 in X 85 on the south-eastern side of Big Stone bay. All the directors were residents of Winnipeg. Work was commenced on the property in 1883, a five-stamp mill was erected, a shaft house, mill house, boarding house, assay house, blacksmith's shop and other necessary buildings. Work was continued for part of two years; a large quantity of ore was milled, but I do not know what it yielded. Operations ceased, I think, in the early part of 1884, in the winter, owing to the want of funds. Thirty to forty men were employed and about $15,000 was expended. The mill was not well suited for its work, and the managers had not a sufficient knowledge of milling gold ore to make proper use of the equipment they had. The miners employed in the shaft were so well satisfied with the showing that they proposed to work it themselves, paying their wages out of the output, and they worked on this understanding for a week or so when they quarrelled with the managers. It was the general opinion that under good management the mine would be a paying investment, and the miners had no doubt that, had they been allowed to go on, they would get their arrears of wages out of it.

The Winnipeg Consolidated mine.

George Mitchell—I am a conveyancer and mining broker, and reside at Rat Portage. I have had practical experience in mining development in this section, particularly in connection with the Winnipeg Consolidated. I think this district should be placed in the front rank of gold yielding districts on the continent. I have seen free gold taken from at least twenty different veins here. On the Winnipeg Consolidated our mill run gave $48.60 clear across the vein from five tons of rock carefully crushed. There was also a good deal of slaty matter in the gangue, and a good deal of gold found its way into the tailings. The test referred to was made from ore taken at a depth of 60 feet, and assays from average specimens of the same ore gave $114. A great quantity of ore was milled, the average yield of which was $43 per ton as near as it could be calculated; the amalgam found in the tailings gave $16 per ton. The ore contained a good deal of arsenical pyrites of iron, a little sulphate of copper, very little argentiferous galena; sulphurets of iron are common in gold veins throughout the district. I have seen arsenic in the Winnipeg Consolidated, George Heenan and Keywadin veins as shown by surface assays. The Winnipeg Consolidated vein was discovered by George McVicar, of Port Arthur, in 1881. It showed about eight inches on the surface, where the

Tests of the Winnipeg Consolidated mine.

Width and course of the Consolidated vein.

shaft was sunk; at a depth of 20 feet it pinched to one inch and then widened out to two feet, which width it carried down to 70 feet; it then took in several small stringers, and at its present depth (about 108 feet) it is four feet between the walls. It is nearly vertical, but dips slightly to the south. The hanging wall is, I think, talcose slate, which also carries gold in small quantities next the vein; the foot wall is trap. The vein appears in straggling form at the bay, and has been traced about 600 feet 10° to 15° south of east of the shaft.

Woodchuck gold location.

Robert Bunting—I live at Rat Portage, and own the Woodchuck gold location in company with John Little of Selkirk. The property is on Clear Water bay, Lake-of-the-Woods, being 71P, and consisting of 330 acres. The vein was discovered in 1883 by Little and Joseph Thompson. I acquired an interest in the property about four years ago. The vein is about eight inches wide at the top, and at the depth of 16 feet it widens to four feet. Two pits were sunk about three years ago, one 8 feet deep and the other 16 feet. The ore shows free milling gold, and is easily extracted by burning and pounding. I have never had an assay made and do not know what it would yield, but it is well distributed throughout the vein matter.

Boulder Island location.

Dr. Henson—I have resided at Rat Portage about nine years and am a medical practitioner. I was one of the first to explore for gold in this region, commencing in 1879. Along with William Gibbons I made the second discovery of gold, which was on Boulder island in Lake-of-the-Woods. The first was made a few weeks before on Hay island. I also discovered the Manitoba Consolidated on the north side of Clear Water bay, being on the Argyle lead. A half interest in the Boulder island location was given to Alexander Manning and others of Toronto on condition of erecting a five-stamp mill and opening the vein. The vein was stripped about 75 feet and a lot of fine free gold taken out, but the mill was run only four days; work then ceased, but for what cause I do not know. The mill was taken away and the property has reverted to Gibbons and myself. It consists of 5½ acres which was purchased from the Crown Lands department for $1 per acre. The patent has not issued because the island is in the Keewaydin Lumber Co.'s limit. The Manitoba Consolidated was opened about six years ago by the Manitoba Consolidated Co., of which Hugh Sutherland was president. The nominal capital was $2,000,000. I got for my share a certificate of $20,000 stock, non-assessable. I do not know how much of the stock was paid up. A shaft was put down beside the lead a depth of about 75 feet. The vein is nearly north-east and south-west, is four feet wide, and nearly vertical; it consists of white quartz containing free gold and a little silver. As the vein is at the water's edge it was intended to sink the shaft alongside it to a point below the water level, the cliff being 75 feet high, but just when the proper depth was reached the work was discontinued; I do not know for what cause, but think it was for want of funds. I saw specimens of gold taken from a location on Seine river, Canadian side, in the possession of Mr. Pither, Indian agent at Fort Francis; it was quite rich in free gold.

Manitoba Consolidated location.

The Lake-of-the Woods discoveries.

S. J. Dawson—The Lake-of-the-Woods discoveries are something wonderful. I have followed the vein in one case over half a mile, and in pieces broken off with a hammer specks of visible gold were shown. The vein was three or four feet wide; the character of the gangue was quartzite, very hard but in some parts decomposed. A good deal of development work has been done at the Sultana mine and at the Pine Portage mine.

The Sultana island location.

George Heenan—I have lived at Rat Portage since 1878, and have been more or less occupied in exploring for minerals since that time. I have seen various kinds of minerals on Lake-of-the-Woods, such as gold, galena, antimony, native copper, and I am satisfied that plumbago exists in considerable quantity, but I have been interested only in gold. I am provisional director of the Ontario Mining Co., which owns nearly the whole of Sultana island and its extension on the main land, about 670 acres, part owner of the Keewaydin location and of the George Heenan, both on Hay island, of a location on Shoal lake, and several others on which no development has been made. The Ontario company is not yet incorporated, but about 15 persons are interested in it, mostly residents of Winnipeg and St. Paul. Some 45 veins have been found on the Sultana location, but openings have been made on not more than 15 of them. The location is veined like a checker board with east and west and north and south courses; the courses are not regular. The width varies from 4 to 7 feet and the dip is nearly vertical. The veins occur in granitoid rock, and are quartz, containing free gold in the western part of the island. On the eastern side the veins do not appear to contain as much free gold,

but I think the east side is equally rich. No assays have yet been made, but we find gold in all washings of decomposed vein rock.

F. Miller—I have visited every location in the vicinity of Lake-of-the-Woods, and some of them I think will turn out very well. The Pine Portage I look upon as the best. There is an enormous vein there, over 20 feet wide. On that property there are not less than seven veins. I took average specimens weighing about 150 pounds. and by pounding, amalgamating and crushing I got not less than $143 a ton. The ore is refractory upon the surface, containing antimony, lead, copper, zincblende and arsenical iron pyrites. I detected one or two little specks of platinum. By concentrating the ore and then treating it as refractory along with lead, is in my opinion the best plan of working it. Pine Portage specimens.

GYPSUM.

The gypsum beds of Ontario are found in the Onondaga formation, and almost altogether in the valley of the Grand river from Paris in Brant county to a point a few miles below Cayuga in Haldimand. It is found so abundantly near Paris, in France, that it is commonly known as plaster of Paris, both in the ground and the calcined state. It is composed of lime and sulphuric acid, and hence is called also sulphate of lime. These elements make it valuable as a fertiliser, and the greater part of what has hitherto been produced in Ontario has been used for this purpose. Within the last two or three years, however, calcining works have been started at Paris and in the vicinity of Cayuga, where the manufacture of calcined plaster and alabastine is carried on. The calcined plaster used in Ontario has up to the present been supplied almost wholly by Nova Scotia and New Brunswick; but as an excellent article is now being made on the Grand river, at points convenient for shipment by railway, the manufacturers believe that they soon will be in a position to displace the Maritime provinces plaster in the Ontario markets. Two grades of gypsum are found in the district, the white and the grey; the latter occurs at Paris, and both in the beds lower down the river. The grey gypsum is used chiefly as a fertiliser, it being unsuitable in color for alabastine, stucco or any kind of ornamental work; the white answers for any purpose, but should the demand increase it will doubtless be used chiefly in the arts hereafter. Large quantities are so used in the United States, the greater part being manufactured from imported stone. In 1886 the product of calcined plaster in that country was 72,200 short tons, of which 46,000 tons was made from imported stone, and in 1887 it reached 81,000 tons, of which 54,000 tons was from imported stone. The total product of land plaster in 1887 was 106,000 short tons, of which 61,000 tons was made from imported stone. The chief sources of supply in the United States are the deposits in Michigan and Ohio; but gypsum has also been found in Dakota, Colorado, Wyoming and California. Owing to the distance of the western quarries from market, however, it is only in California that the industry has developed to any extent. Gypsum will not bear long transportation, either in the crude, ground or calcined state, especially in the crude.

Location of the deposits.

Uses of gypsum.

White and grey varieties.

Production in the United States.

The gypsum deposits on the Grand river occur with layers of dolomite and shale, and ore usually in the form of mounds or hillocks of diameters ranging from a few yards to half a mile, from three to seven feet in thickness at the centre and gradually thinning off towards the circumference. The Occurrence of the Grand river gypsum.

overlying strata rest conformably upon these mounds, so that the presence of a gypsum deposit in a locality may be determined by the mound-form of the surface. The beds are never continuous for long distances, the gypsum being found almost always in lenticular masses.

Theories of the origin of gypsum.

Various theories of the origin of gypsum are entertained by geologists. By some it is supposed that it has been produced by the action of acid waters upon the calcareous strata through which they pass, forming a sulphate of lime which might be deposited in dome-shaped masses at the surface like the cone of a volcano; but in the opinion of Sir William Logan the beds on the Grand river seem to have been in all cases contemporaneous with the shales and dolomites in which they are interstratified, and to have no connection with the acid springs of the present time. The hillocks in which the gypsum occurs, he thought, appear to be due to the fact that the masses of gypsum, or hard beds immediately overlying them, have resisted the denudation to a greater extent than the softer argillaceous strata, which seem elsewhere to make up a great portion of the formation. The fact that dolomites, magnesian marls and limestones are invariably found associated with rock salt, gypsum and anhydrite (the waterless form of sulphate of lime), have led some geologists to suppose that they are the conjoint products of chemical reactions in which they have severally had part. The rock salt and gypsum form lenticular masses, or else appear through the enveloping strata in strings or veins. In a salt lake or enclosed sea subject to excessive evaporation the reaction of bicarbonate of lime on sulphate of magnesia may produce gypsum, and the gypsum and salt readily separate from highly saturated waters. The layer of gypsum near Sandusky, in Ohio, is believed by the Ohio geologists to have been deposited in a closed and shallow sea, and they reject the theory of spring formation as untenable. Prof. Prestwich also leans to the theory of separation and deposit in an enclosed sea, and mentions the remarkable case of the artesian well at Sperenberg where the bore-hole passed through 283 feet of gypsum and anhydrite and 3,769 feet of rock salt. But he adds that while we may form some notion of the chemical reactions which led to the deposition of those beds, it would seem that the conditions under which they were effected must have been very different from anything of which we have any experience.

Origin of the dome-form.

In explaining how the dome-shape of gypsum may have been caused, Prof. Prestwich describes what takes place by the action of underground waters on anhydrite—the waterless form of gypsum. "As the water of hydration in gypsum amounts to more than 20 per cent., when the anhydrous sulphate of lime passes into the hydrated sulphate a great increase of bulk takes place, and this is effected with a force analogous to that of freezing water. Such is the underground force that the anhydrite will under these circumstances lift masses of strata into dome-shaped hillocks, sometimes of considerable size. Some instances have been described in which the enclosing strata are thrown up vertically, or are even reversed, by the sides of the mass of gypsum."* Assuming the Grand river gypsum to have been deposited as an anhydrite, the hillock form is readily understood upon this theory.

* Prof. Prestwich's Geology, Vol. I, p. 116.

David Brown—The Alabastine Co. of which I am president was organised about three years ago with a capital of $28,000. The shareholders are partly Americans and partly Canadians, but the greater part of the stock is held in Canada. There is a company of the same name in the United States; they own the patent there and we control it in Canada. We manufacture land plaster, calcined plaster and alabastine; we have also just commenced the manufacture of plastico under another patent. We have 65 acres about two and one-half or three miles below Cayuga, which yields white gypsum. We are mining there but are manufacturing at Paris. The bed of gypsum is about four feet thick, but more in some places and less in others. We mine from a shaft sunk on an incline. The gypsum is brought from there to Paris, where it is manufactured into calcined plaster, alabastine and land plaster. We have not yet had time to devote to the land plaster trade. The object of the company is more for the manufacturing of alabastine, and we have been pushing that. The calcined plaster has given satisfaction as far as it has gone; there is no reason why it should not, as the material is all right. Nova Scotia supplies most of the plaster that is used, and it is somewhat difficult to replace it. Plastico is for mouldings and such work, about the same as stucco, but I cannot say much about it as we have only just commenced to make it. To make ababastine we select the gypsum, screen and calcine it, then mix it with several ingredients that are secret. The quantities are measured, ground and mixed by machinery, so that it is exact and uniform. It is put up in packages of about five pounds each, and twenty in a box, and is sold that way to the trade. Alabastine will cover twice the space that the same amount of calsomine will. It can also be used as a primer for paint. During the last two years we have sold about 75 tons a season, and we expect to sell 100 tons this year. The gypsum of the Paris mines is grey. It is about 100 feet under the surface, and we mine by striking it from the foot of the hill. The bed is from four and one-half to six feet in thickness. We make our land plaster altogether from the material found here. Our sales of plaster for the last three or four years have been about 1,500 tons. We don't make more than 400 or 500 tons of white land plaster. About 2,500 tons would be the total gypsum we use in a year. The land plaster is sold as a fertiliser, and we contend that the grey plaster is the better for that purpose. I don't think there is any fertiliser that is so good and costs so little. All our sales are made in Canada; we have not shipped any gypsum to the States for a number of years. Our land plaster trade is limited to Ontario, but the alabastine goes all over the Dominion. The calcined plaster is sold only in Ontario and Manitoba.

The Alabastine company of Paris.

Products of the works.

The Paris gypsum.

Markets.

Alexander Gill—I have been engaged in the plaster business for twenty-four years. When I went into the business in 1864 it was altogether a retail business. In 1865 we shipped 1,200 tons of gypsum. In 1866 we ran it up to 4,200 tons, about 2,000 tons being retail. In 1867 we ran up to 8,500 tons, the retail trade going down to 1,600 tons. Next year the business went to 10,400 tons, and after that it kept going down till in 1875 it was only 4,300 tons. I went out of the business then, but after various changes myself and Mr. Brown acquired the property. Land plaster does not sell as well as it used to; twenty-three years ago I loaded teams from Owen Sound, but to-day we cannot send it there at all. Then the price at the mills was the same as now, $4.50 a ton. When a person takes ten or twelve tons we sell it at $4 a ton. The wholesale price on the cars is $3.75. If we sold the same quantity as formerly we could make more money, under the improved way we have of handling it. Formerly it took thirteen men to run the mill night and day, but now we can run it with three men. We use water power altogether. We used to pay 85 and 90 cents for mining here. At Cayuga it costs us about $1.10. We claim that our gypsum makes as good alabastine as the American.

Early production of the gypsum quarries.

Economic handling.

Robert Glenny—I have been engaged in mining plaster for twelve years. Within the last four years I have been engaged in the manufacture of the plaster. Our works and mine are about four miles from Cayuga. I think it must have been forty years since that mine was first opened. The bed of gypsum is about four feet thick, or perhaps a little more. The Grand River Plaster Works company have two mines here, the lower being the Merritt mine; the upper was mine till I sold out to them. The Merritt mine is worked on a level drift without any incline; the Glenny is on an incline of 1 in 10 for about 100 yards. The gypsum at the Glenny is about 42 or 43 feet from the surface; at the Merritt it is not so much. The roof is supported with timber, and the whole face is taken as we go; sometimes we leave a pillar. I

Grand River plaster works.

think the production is upon the decrease. In the last four years about 1,500 tons a year have been taken out and disposed of. The Glenny mine was opened about ten years ago, and it was the only one shipping from here then. I understand that many years ago, before the discovery of gypsum in the States, thousands of tons were exported from here. We started calcining and the systematic manufacture of stucco last year; before that some had been done on a small scale. We have one kettle, with a capacity of about 40 barrels, a crusher and a disintegrator, besides a set of stones. The weight of the barrel is about 250 pounds. Our intention is to have it set about the same as the New Brunswick plaster. What we have manufactured has been as white as that made in New Brunswick and Nova Scotia, and it is finer ground. Our land plaster is sold in bulk, barrels and bags. It goes as far as Brockville to the east and Windsor to the west. I do not know the cause, but I think the demand for land plaster is rather upon the decrease. I have been over a good deal of Ontario, and never heard it said that it was not a good fertiliser. It is used sometimes in stables to fix liquid manure. I know of land plaster being imported from Oswego only. It is grey, and I do not think it is as good as ours. The number of men employed during the last three years ranges from 3 to 20. For the last year from the middle of June to October we did not employ any at all, but for the rest of the year we had about 10 men, two of whom are skilled men and the rest laborers. The engineer gets about $1.55 a day, the laboring men about $1.25 and the calciner over $2. There is no gypsum below the Merritt mine. Three miles above is the Alabastine Co.'s mine. There is gypsum on the Anthony farm beside the Alabastine Co.'s property, but it is pretty thin there. The next above is at Mount Healy a mile below York; that property was worked last year, and is I presume in working order; it has been worked about twenty years. Next above that is a mine at York; I think Mr. Martindale works it regularly. His mining is principally done in the winter, and I think he does not do as much as formerly. He used to calcine some, but has not done so lately. His plaster is of fair quality, and he has a water mill for grinding it. The next is about three miles from Caledonia, and I believe there is none again till we get to Paris. The one near Caledonia is called the Garland mine. I am told that for part of 1887 and 1888, which would be the busy time, about 700 or 800 tons were mined there. We take out the gypsum by blasting with powder, and it is a poor shot that would not fetch a ton. I understand that $50,000 is the capital of our company. Warren Ackerman is the president, and the headquarters of the company is at New York; E. W. Dodd is the secretary. We have sent some of our gypsum to Newburg, N. Y. Out of the 1,500 tons we ship about 600 tons in the rock. The price last year was $3.75 f.o.b. the cars at Cayuga for ground land plaster. We sell at $3 f.o.b. the boat on the river. The rock gypsum sells at about $1.50 a ton. We ship some to Cleveland and Erie. There are several points on the American side of the lakes where they grind plaster. There is a duty on manufactured plaster coming into this country, but I don't know what it is. In the States there is a duty on manufactured land plaster of 50 cents a ton. The rock gypsum is free. If the Welland canal feeder that comes up to the works were made deeper, or a lock put in at Dunnville, it would do a great deal to develop the business. As it now is, it costs too much to get to Lake Erie.

Calcining for stucco plaster.

Land plaster.

Other gypsum locations.

Markets and prices.

L. J. Johnston—I am a merchant in Caledonia and have been working a gypsum bed in the township of Oneida, three miles south of Caledonia, for six years. Garland worked it twelve or fifteen years before I got it. It has been worked pretty much continuously. I got out last year about 800 tons; the year before I did not get out any; before that 600 or 700 tons a year. We take the gypsum out mostly in the winter and stop in the spring when the roads are not good. The bed averages about five and one-half feet thick. In the bed there are little streaks of blue, but the grain is finer than that of the Merritt mine. Where I am now working it is solid white gypsum. Under the gypsum there is rock, and over it rock also—a shaly clay rock. We grind with stones like wheat; the power is water power. We sell all over the western country, west of Toronto. I have shipped to the States. The first year I had the mine I calcined some and made a first class plaster; I made only ten or twelve tons as an experiment. I generally employ about two or three miners, one man drawing out, and three or four men teaming. The miner gets 70 cents a ton delivered at the mouth; he furnishes his powder, light, and tools; the rest of the laborers are paid a dollar a day. I pay 40 cents a ton for the drawing, and the teamsters make about $2.50 a day. Land plaster is good in stables, is a good fertiliser and would be good for country water closets.

Mining in Oneida township.

IRON.

During the trip of the Commission only one iron mine was seen in Ontario producing ore, viz., the Wilbur mine on the Kingston and Pembroke railway. All the other deposits visited were either undeveloped or lying idle and full of water. At the Coe Hill mine in Madoc, some 30,000 tons of ore were lying waiting for a market. The iron carrying districts visited by the Commission were: (1) On the north shore of lake Huron, where an extremely fine quality of specular and micaceous hematite is found in places from Killarney to Sault Ste. Marie, in the Huronian formation. No large deposits have yet been opened up in this district, but the indications and prospects seem to be very favorable. (2) The McKellar location on Antler or Attic-Okan river, south-west of lake Shebandowan. (3) The Vermilion iron range in Minnesota, which extends northward into Canadian territory. (4) The Madoc district. (5) The Kingston district. (6) The Perth district. The last three are in eastern Ontario, and form parts of the same iron-bearing formation. A few locations are alluded to briefly, particulars being fully entered into in the evidence. Iron locations.

Some valuable contributions on the iron ores of Ontario are to be found in the publications of the Geological Survey, amongst which may be mentioned, Iron and its Ores, Sir William Logan's Report of 1863; Studies upon the Ores of the Dominion and the best Modes of Working them, by Dr. Sterry Hunt, in the Report of Progress, 1866–69, and Iron Ores and their Development, by Dr. Harrington, in the Report of Progress, 1873-4. Geological Survey reports on iron.

In the north-west corner of the Wallace mine location, on the north shore of lake Huron, a vein or bed of iron ore occurs in quartzite. It consists of about eight feet of banded ore and quartzite. The ore varies from crystalline to compact specular. The bed may be traced some 200 or 300 yards westward, and is but two feet across where last visible. Towards the east a mass of *debris* and a steep declivity prevent its being followed without exploration work. Where the ore is solid it is of an excellent quality. In going out to this location from the lake shore, diorites, quartzites, chloritic and talcose schists and a light grey quartzose felsite are crossed. Wallace mine location.

MINNESOTA VERMILION RANGE.

The Vermilion iron range in northern Minnesota was visited by three members of the Commission in the latter part of the month of August, to examine its character, because it is believed to extend into Ontario. The specimens obtained and evidence collected give good grounds for little or no doubt that this is the fact. The Vermilion and parallel ranges have been traced for some distance on American territory, running north-easterly towards the Ontario boundary. In this direction from the Vermilion range many locations have been taken up on our side of the boundary, principally by Americans who are interested in iron mining. Ore was shown us by responsible people which was said to have been taken from the Ontario side, and some of which was of very good quality. Iron ore in various grades of quality has been found in places, extending from the boundary past the Kakabeka Falls district. It is altogether probable that valuable deposits will be Vermilion iron range. Its probable extension into Ontario.

Importance of exploring the region.

developed on the Ontario side, and it is of the utmost importance that information should be obtained regarding the ores in this region. The small samples which have been seen are chiefly of magnetic ore, but comparatively little exploration and practically no development has yet been carried on. No iron mining can be successfully undertaken without a railroad, and if prospectors or the holders of lands thought a railroad was sure to come if they showed development enough to warrant it there is reason to believe that they would at once begin work upon their claims. The government of Minnesota has by grants of lands largely assisted a railroad which is now pushing northward toward our boundary. The iron development in the northern part of the state justifies the building of this road, which is now carrying to lake Superior ports about 400,000 tons of ore per annum from the mines in its vicinity. The ore deposits are very large and exceptionally rich, being of the red specular variety, and as a rule of a Bessemer grade. The present centre of this iron region is the town of Tower, on Vermilion lake. Two ranges of iron are found here, the Vermilion, which practically yields all the ore at present, and the

Iron development in northern Minnesota.

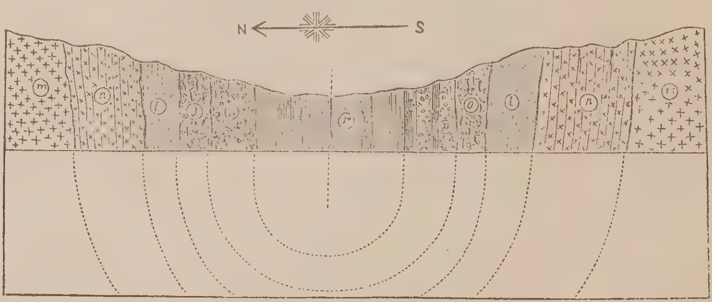


FIG. 12. Theoretical folding of the Vermilion series of schists.

m. Granite. n. Gneiss. l. Mica and hornblende schists. o. Greywacke. p. Argillite. r. Sericitic and chloritic schists and iron ores.

Parallel ranges of ores.

Mesabi, twenty miles further south. The ore in the latter is said to be more magnetic, and is found in a blanket or flat formation. Possibly another parallel range occurs to the north of Tower, in Hunter's island in Ontario, where iron ore is found. The deposits at Tower have been opened up in several places, and are in a position to turn out 40,000 tons a month. They are known respectively as the Brighton, Tower, Ely, Stone and Stuntz mines. The ore dips 70° north, and strikes about east-north-east and west-south-west. It varies from 100 feet in thickness at the Tower mine to ore bodies of 20 to 50 feet in thickness as worked at some of the other openings, and occurs with jasper to the north, dipping to the north, and talcose or chloritic shales on the south side. It is stated that the ore always dips to the jasper and under it, that is, the jasper is found over the ore. Fig. 12 shows a theoretical cross-section of the Vermilion range, taken from the report of the Minnesota Geological Survey for 1887. From this it would seem that the strata of the formation have been folded to the form of a synclinal trough, in the middle of which the ore is found. If this be a true section it may be inferred that the ore body is of limited depth, being circumscribed by the folds of the formation.

The Tower mines.

North Lee mine.

At the North Lee mine, half a mile south of the Tower mine range of deposits, a body of ore varying from 20 to 50 feet wide runs east-north-east and west-south-west, and dips to the south. It lies with jasper on the south side, and "soap rock" or a close grained chloritic diorite, partly decomposed near the ore, on the north side. The ore is worked in an open cut by stopes 50 to 60 feet high, changing to a jaspery rock at the end of the cut; but at this mine the ore has too much phosphorus for Bessemer iron. Fig. 13 represents the run of the two ore bands half a mile apart. The northern ore band dips to the north, and the southern at the North Lee mine dips to the south, although the formation, as exposed before reaching the excavation on the ore, dips to the north. The formation close to the North Lee mine consists of alternate layers of jasper, grey quartzose rock, quartz and specular iron ore, making a very handsome rock, with white, grey and red streaks. These ranges come to an abrupt end in a short distance as far as tracing the ore is concerned, but in a north-easterly direction they extend as far as Ely, a distance of about 21 miles. A railway has been constructed to the latter point, a distance of 96 miles from Duluth, or 70 miles from Two Harbors on lake Superior, which is the shipping port for ore. At Ely a large mine has been opened up during the year, and considerable quantities of ore have been shipped.

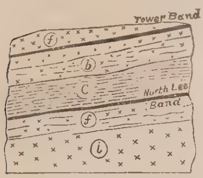


Fig. 13.—*b. Chloritic shales with thin streaks of jasper and quartzite. c. Chloritic shales. f. Jasper. j. Diorite.*

Dip of the ore bodies.

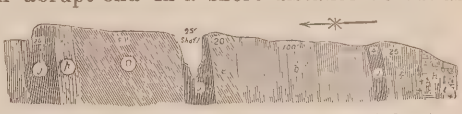


Fig. 14. *b. Shale. c. Jasper. f. Jasper and shale mixed. h. Shales. i. Diorite. j. Ore. o. Jasper with ore stringers. p. Ore and jasper.*

The Ely mine.

Statements of miners and prospectors.

Statements procured from miners and prospectors at Tower and Ely are appended, which give important information on the work carried on at this place, as well as of explorations farther north and on the Ontario side of the International line.

Iron mining at Tower, Minnesota.

D. H. Bacon—I am manager for the mining company at Tower. The total capital of the company is $14,000,000 all paid up, and it owns both the railway and the mines. The company received from the state of Minnesota a grant of 500,000 acres of swampland besides 2,000 acres at Two Harbors, its port on lake Superior, and 12,000 acres of mineral land at Tower. The railway extends from Duluth through Two Harbours to Tower a distance of 96 miles, and recently has been extended to Ely a further distance of 21 miles. It was completed from Two Harbours to Tower in 1884, (the first cargo being shipped in August of that year), and from Tower to Duluth in December 1886. In 1885 the total shipment of ore over the line was 75,000 tons; in 1886 it increased to 350,000 tons and in 1887 to 392,000 tons; while to the end of August, 1888, it was 250,000 tons. The prices realised for the ore have ranged from $2.75 per ton for low grade to $3.50 for highest in 1887, and from $2.50 for lowest to $3.25 for highest in 1888. The company employs 1,000 men in summer and 750 in winter, and its pay-roll for the month of July last was $54,000. Four thousand people are depending upon the industry for a living at Tower. On the developed mines of the company diamond drill explorations have been made to depths of 300 to 400 feet, showing widths of ore at these depths ranging from 38 to 50 feet. The earnings from its mining operations over and above all expenses to May 1st, 1888, were $473,873.

Shipments and prices of ore.

Exploring Hunter's island.

Michael O'Keefe—I have explored part of Hunter's island north of Emerald lake, and traced a deposit of iron ore for some distance northward. I think that it passes under a lake about five miles long, as I found outcroppings beyond the lake. I have traced the deposit a total distance of eight miles, and the width varies from 50 to 300 feet. I have taken up a location of 80 acres. The specimens

I have from this location are very hard, and one of them is jaspery. I understand that at one of the mines at Tower the jaspery ore and rock was 40 to 50 feet in thickness.

Exploring Ontario north of Knife lake.

James Sheridan—I have explored Ontario on the north side of Knife lake. I have found iron ore and bought a location there. I consider that it is in the same Huronian belt as the Vermilion range. The ore is mixed with jasper in the same manner, and the walls are diorites and chloritic slates. The deposit is 90 feet wide and assays run from 47 to 56 per cent. of iron. I think it will average about 50 per cent. of iron, and it is low in phosphorus and sulphur. It is a red hematite, but somewhat hard and silicious. The bed can be traced for three miles along the strike. Only a small part of the country has as yet been looked over.

The Chandler mine at Ely.

Mr. Sellwood—I am manager of the Chandler mine at Ely. Work commenced regularly on our property last winter, but previously it had been well explored by diamond drilling. An open quarry shows a large extent of crumbled hematite ore, and a shaft has been sunk 100 feet into the deposit with drifts east and west about 400 feet; 190 miners and about the same number of strippers are employed, and the pay-roll is $12,000 per month. The owners of this property are the principal shareholders of the Minnesota Exploration company and of the Minnesota Mining company, but the stock has not yet been assigned. I have explored the country 65 miles to the eastward and found a good quality of black ore.

Ore specimens from the Ontario frontier.

Mr. Sloan, a Canadian from the vicinity of Montreal, showed a specimen of magnetic ore of very good quality, found within seven miles of the frontier, and told the Commission that he had seen samples of good ore found on the Ontario side.

Rich iron ore in Ontario territory.

William Sedgwick, superintendent of the Barnum mine at Ishpeming, Michigan, gave information relating to the occurence of rich iron ore on Ontario territory, on the north side of Gunflint and North lakes, and presented specimens taken from these districts. Following is a sketch of the region furnished by Mr. Sedgwick:

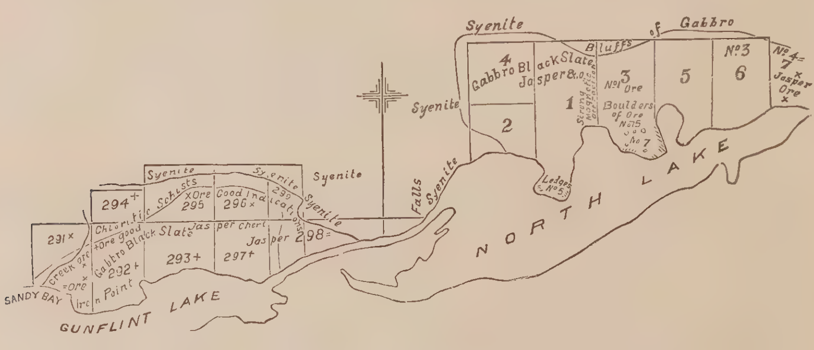


FIG. 15. Sketch of section of country in Ontario near the boundary. Scale, 120 chains to one inch.

Mr. Sedgwick has supplied the following information respecting the iron ores in the vicinity of Gunflint and North lakes:

Gunflint and North lakes district.

On the north side of Gunflint lake there is a rich magnetic iron ore suitable for making Bessemer steel. It analyses 68 per cent. iron, .028 per cent. phosphorus, no sulphur and very little silica. I satisfied myself that there was at least 25 feet in thickness of this ore, but how much more I did not wait to determine, lest some one would take advantage of my discovery and purchase the property from the Government before me. I also obtained specimens from drift boulders and ledges of good quality ore at several other places on the north side of the above mentioned lakes. I visited this locality last summer and had with me an experienced explorer and a party of miners, but the question of transport is such a serious item that under present circumstances it is impossible to do any work of development. I consider that the only possible way to have the iron worked in this locality is to build a rail-

road ; and that before work enough was done on the iron ore deposits to prove their size, and therefore justify the construction of a railroad, means of ingress and egr ss is an absolute necessity and should at once be provided. This can be done cheaply by continuing the road from Silver mountain to Whitefish lake, and making a good road over the few intervening portages between Whitefish and North lakes.

Importance of railway communication.

MINES AND LOCATIONS IN EASTERN ONTARIO.

Blairton iron mine.

The Blairton iron mine is on lot 8 in the 1st concession of Belmont, in the county of Peterborough, and has been fully described in Sir William Logan's Geology of Canada, 1863, page 676. A large and deep excavation has been made, 150 feet wide by 250 feet long, but it is now filled with water. A second opening, also full of water, lies to the south of the first, but is much smaller in size. On the east side the deposit is over-capped by Silurian limestone, while the west wall is a jaspery quartzite. The strike of the deposit is to the west of north. The ore as seen on the dump is a rich magnetite. In the smaller pit ore of a lean character is seen dipping to the north-east, but elsewhere it has been mined away. In the wall, quartz and serpentine matter predominate.

S.W. N.E.

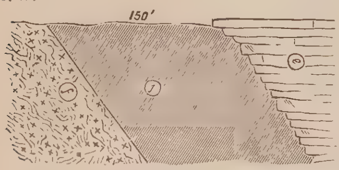


Fig. 16. Formation at the Blairton iron mines. *e. Silurian limestone. f. Jaspery quartzite. j. Ore and accompanying rock matter.*

Wallbridge mine.

The Wallbridge mine in the township of Madoc is a well-known ore bed of excellent hematite. A lense of ore has been worked down to quartz rock, which rock is also thrown up to the north-west side along with crystalline limestone. This deposit has the character of the Huronian hematites seen in northern Michigan.

Coe-hill mine.

The Coe-hill mine is situated in the township of Wollaston, in the county of Hastings, at the northern terminus of the Ontario Central railway. Three shafts have been sunk upon the property along a north-east and south-west line, but as they were filled with water the ore body could not be examined. Its apparent width where excavated seems to be about 40 feet. The dip is 45° south-east, with syenite on the hanging wall and diorite on the foot wall. A large quantity of ore (about 30,000 tons) lies on the dump. It seems to be a rich quality of ore, but some of it carries iron pyrites. Fig. 17 is a section of Coe-hill mine, as given by Mr. Coe.

S.E. N.W.

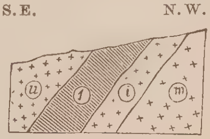


Fig. 17. Section of Coe-hill mine. *i. Diorite, 28 feet. j. Ore, 45 feet. m. Granite. u. Syenite.*

Formation on the K. & P. Railway.

The rocks north of Kingston, as exposed along the line of the Kingston and Pembroke railway, are chiefly crystalline limestone, gneiss and syenite, and as a rule no diorite or greenstone dykes or bands are prevalent. An exception is found, however, nearer to Kingston than the chief ore deposits, where phosphate of lime is found in pyroxenic rock. The iron occurs with the crystalline limestone and sometimes enclosed in it ; or more often with one wall of gneiss or syenite and the other of crystalline limestone. A certain amount of pyroxene is always found with the magnetic ore. No hematite has as yet beeen developed along the line of the railway.

The Glendower mine is situated in the township of Bedford, in the county of Frontenac, four miles east of the Kingston and Pembroke railway, with which it is connected by a switch built in 1884. Crystalline limestone forms the wall rock on the south side of the ore occurrence, and a coarse-grained grey syenite forms the country rock on the north side, but the limestone forms the immediate wall rock on both sides next the ore. The ore is a magnetite, mixed with pyroxene and calcspar masses. The bed seems nearly perpendicular, but dips slightly towards the south. The ore exposed on the dump carries a considerable percentage of iron pyrites, which however is said to be local; the shaft is filled with water. Ore has also been mined as an open cut into the side of a hill, where it occurs as parallel bands in the limestone. It is coarsely crystalline and mixed with hornblende in places, the latter carrying iron pyrites with it in the rock. Most of the ore at present visible seems to carry some pyrites. The ore formation strikes nearly north-east and south-west, and it is stated that the belt is traceable, as indicated by deposits, for 20 miles to the north-east. The railway cutting along the switch shows a great many crystals of hornblende in the limestone, running at places in veins or streaks and dipping and striking at all angles.

Glendower mine.

The Calabogie mine is in the township of Bagot, county of Renfrew, on the line of the Kingston and Pembroke railway. It has been worked for 400 or 500 feet along the strike, and, it is stated, to a depth of 100 feet, but the opening is filled with water. The dip is 35° to the south-east and the strike north-east and south-west. The deposit consists of a banded series of pyroxene schist and pyroxene rock mixed with much calcspar, micaceous in places. The ore occurs, especially in the lower part of the series, bedded in with the rock, but what is visible is low grade. Above the over-lying ore series is a thick bed of greyish and yellowish limestone. It is the property of the Calabogie mining company.

Calabogie mine.

Calabogie mine No. 4, also the property of the Calabogie mining company, is on lot 16 in the 8th concession of Bagot, a mile and a half in a direct line east of the Kingston and Pembroke railway. The ore bed strikes north-east and south-west, and dips at a high angle to the south-east. The opening is about 20 feet wide, but no ore is visible at the outcroppings excepting some of a low grade. A considerable quantity lies on the dump, and is a compact, glistening, magnetic ore mixed with some crystalline limestone or calcspar and a little dolomite and pyroxenic matter, and also iron pyrites in places. The ore occurs with hornblendic schist, a grey quartzose rock and a micaceous schist. Felspar is present in small crystals. This ore is said to have too much phosphorus for Bessemer.

Calabogie mine No. 4.

On lot 16 in the 9th concession of Bagot is a location owned by Mr. Coe of Madoc. It is on the same range as the previous mine, and lies about 600 feet to the south-west of it. The ore as here exposed is a magnetite, and has been shown up by an open cut into the formation, but as it was full of water only the outer part could be examined. The ore alternates with pyroxene rock and calcspar, and is shown to be 20 feet wide by the cut. It occurs in bunches, the north side of the cut showing a much larger quantity of ore than the south side. It appears to be a good, rich quality of ore, and it is reported

Coe location.

that this iron range can be traced for two miles running in a north-east and south-west direction.

The Wilbur mine is in the township of Palmerston, in the county of Frontenac, on the line of the Kingston and Pembroke railway. There is an ore-bearing formation with gneissic rock for foot wall, and lying between two bands of crystalline limestone. The ore occurs as lenses, and is chiefly associated with pyroxene in various forms. It is close textured, of greyish color and mixed more or less with pyroxene. The strike of the formation is south-east and north-west, and it dips 35° to the south-east. Fig. 18 represents a section of country at the Wilbur mine. Five openings have been made within a distance of a quarter of a mile, in some of which the ore lenses have been worked out. At the south-west end it is still said to be holding out in the workings, and in the other direction borings have been carried on with a diamond drill in the hope of discovering other deposits.

Wilbur mine.

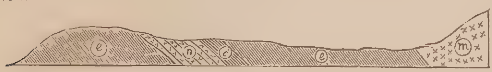


FIG. 18. Section of country at Wilbur mine.
e. Crystalline limestone. i. Ore formation with hornblendic matter. m. Granite hills. n. Gneiss.

Fig. 19 is a section of the ore formation as seen at one of the openings. Where quartz occurs with the ore pyrites comes in, but as a rule no pyrites is found with the ore. The ore lens near the top has been sunk down upon to a depth of 180 feet for an average width of about 50 feet. The miners are now working out the ore at the surface, and throwing the refuse rock into the pit from which they say all the ore has been taken. The diamond drill was occupied in boring toward the north-east end of the prospected ground, and 40 feet of ore was reported to have been crossed, towards which a gang of miners was commencing to work from the outcrop. The drill we were informed goes through 40 feet of crystalline limestone per day.

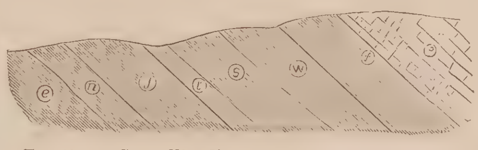


FIG. 19. *e. Crystalline limestone. f. Mixed limestone with hornblendic schist (green). j. Ore and hornblende rock (quartz in places). n. Grey and reddish gneiss. s. Ore bed —(banded structure with calcite streaks parallel to rocks). t. Band of quartz (thin). w. Hornblendic schist and compact pyroxenic rock with ore streaks.*

A number of hematite locations in the township of Darling, county of Lanark, are held by Mr. Bell of Arnprior. They consist of parts of lots 22, 23 and 24, and lots 26 and 27 in the 11th concession, and lots 26 and 27 in the 12th. Where exposed the ore appears as gash veins or irregular masses of hematite, varying from six inches to twelve feet wide, and occurring in a breccia of calcspar with the same as a lime matrix, and the general run of the ore is with the formation. In places the hematite is the matrix of the calcspar masses. Openings have been made in several places, but very little work has been done on the property. This hematite carrying formation is reported to run north to the Ottawa river, near Arnprior, and south to the Perth district.

Bell's hematite locations.

At the Arnprior mine, which was opened many years ago, Mr. Bell states that 10,000 or 15,000 tons of hematite was taken out, when the work was stopped in consequence of the ore being cut off by a fault. The run of

Arnprior mine.

the ore at this place is stated to be north-east and south-west, and is 40 feet wide. The same vein is said to have been traced for five or six miles.

Tamworth hematite.

Hematite mixed with a dark-colored shale occurs near the village of Tamworth, at the terminus of the Napanee and Tamworth railway, in the township of Sheffield, county of Addington. Several pits have been sunk at points from 20 to 100 feet apart, from some of which red ore has been taken out; but in every case the pits ran into crystalline limestone, which underlies the occurrences of ore and crops out about 200 feet off. The quality of the ore varies from very lean to rich hematite, but there are no signs of the existence of it in large quantity.

Haliburton district.

The Commission had not time to visit the Haliburton district, but it will be seen that much evidence has been given bearing upon it. One of the Commissioners, however, has visited the district, and from what he has seen and the information he has gathered he does not doubt that there are a large number of iron ore occurrences throughout an extensive section of that country. Some of the ores are of great purity, while others will require calcining to remove the sulphur; but development is needed to prove the quantity in which they exist. Some large deposits are reported, the ore of which contains too much titanium for use. Operations are now being carried on at the Howland mine, some account of which is given in Mr. Pusey's evidence.

Extent of the iron ore area.

Thomas Ledyard—I have been giving a good deal of attention to mining matters, mostly in Ontario and not very far from Toronto. We have large quantities of iron ore extending over a considerable space, commencing at Peterborough and going north-east to the Ottawa river, and commencing at Haliburton and extending up the Algoma district. I have not examined many of the locations personally, but I have had many specimens of ores sent to me from all parts of Ontario. I have specimens of magnetite from over fifty different places. In some of the cases I know there are large deposits; in others they require to be investigated. I know of twenty-five different deposits of hematite, some of them no doubt large and some not sufficiently developed to tell yet. The proportion in which the samples have come in has been about two of magnetite to one hematite. There is a deposit 100 miles east of Toronto, about six miles north of Blairton station, Canadian Pacific railway. Professor Heys examined it, and reported it was a bed of magnetite 400 feet long and 250 wide in some places. Experts think 300 or 400 tons a day could be got easily. Mr. Heys made an estimate that there were a million tons within 100 feet of the surface. We put three pits down and several cross-cuts, and it appears to be a solid deposit. The pits are only 10 or 12 feet deep, and they seem to get into solid ore. There is no question but it is a solid bed of ore. As to the quality, analysis by Professor Chapman gives iron 64.26, phosphorus a trace, sulphur .04; titanium none. Broadman's analysis gives iron 65.36, sulphur a trace, phosphorus .002, titanium none. Analysis of the Joliet Steel Co., iron 66.29, manganese .042, phosphorus .024, silica 3.19, titanium none, sulphur none. Analysis by the Cambria Iron Co., iron 68.85, phosphorus .008, sulphur a trace and silica 1.96. To reach the mine would require a spur line of four miles from Blairton village. The Snowdon mine is situated on lots 25, 26 and 27 in the 4th concession of Snowdon The railway runs through 25 and 26 and in front of 27. On lot 26 there is a shaft down about 80 feet and is said to be in good ore. There are several shows on the three lots. The ore is a magnetite. On 27 there appears to be a vein 40 feet wide by 600 feet long; all over there appear to be similar shows, judging by the needle. Analysis No. 1 of this ore shows iron 62.57, phosphorus .025 and sulphur a trace. Analysis No. 2, iron 63, phosphorus a trace and sulphur .023. Analysis No. 3, iron 62, phosphorus a trace, sulphur .025. The analyses were made by chemists of different works in Pittsburg. In two hundred tons of this ore there was hardly any sulphur. There was more sulphur in Pusey's mine, but they seem to have got through it there, and down the shaft they say the ore is very free. On lot 27 there is only one place where it shows sulphur at all. Professor Chapman made an analysis of the ore from 27 in

Magnetic ore at Blairton.

The Snowdon location.

the 13th of Galway as follows: iron 62.87, phosphorus .01, sulphur a slight trace. From lot 23 in the 12th, iron 62.60, manganese 1.27, phosphorus .002 and sulphur a slight trace. There was no titanium in any of those ores. On 23 in the 12th there appears to be a large vein, 60 feet wide; it is a difficult place to commence working, as the vein appears to be at the bottom of a creek. Analysis of Professor Heys of ore from 16 in the 16th, iron 65, phosphorus .04, sulphur .02. There is an analysis from the 14th concession, I don't remember the number, iron 70.04, phosphorus a trace and sulphur a trace; no titanium in either. All these ores should be laid down in Toronto at a rate not exceeding 60 or 70 cents a ton.

Charles J. Pusey—I reside at Irondale in the county of Haliburton, and am engaged in building railways and operating mines. We are building the Irondale, Bancroft and Ottawa railway, extending from Kinmount to Ottawa. It is an independent line and there are ten miles graded and ironed. It is being built to serve the mineral interests of the district. I am president of the Toronto Iron company, which was organised in 1881, and the subscribed capital of which is $150,000, all paid up, principally in properties. We have five locations, one of which we lease, but the others are owned in fee simple. Two are situated in Snowdon and three in Glamorgan. There are 100 acres in the leasehold property and 700 in the other four. We have found minerals in each of these five properties; on the leasehold we have magnetic ore, on the next lot brown hematite, and all the others are magnetic. We have done some development on the leasehold property. It is situated on lot 26, concession 4 of Snowdon, and is known as the Howland mine. We began operations there in 1880 and have worked it at intervals since. We are at present sinking a shaft and have twelve men employed. The surrounding rock is crystalline limestone. We have found no walls yet, and therefore cannot give the width of the vein, for it is a vein unquestionably. We have found an outcrop about 25 feet in diameter. We sunk a shaft 12 by 24 feet, and are down now about 70 feet. At a depth of 25 feet the work was enlarged by extension towards the walls in the form of an ellipse, the longer axis of which is about 65 feet and the shorter about 35 feet, and this was carried to a depth of about 25 feet. There was no wall, but solid iron ore and accompanying rock. At the depth of that room it was narrowed down to 25 feet, and carried to a total depth of 65 feet from the surface. We are now 10 feet below that, narrowed to the size of the shaft, making 75 or 77 feet from the outcrop. The quality of the ore so far as its freedom from phosphorus and sulphur is concerned is about the same all the way down, but it varies in its freedom from rocky matter. The value of the ore has increased as we have gone down, as there is a decrease in the amount of the less valuable ore. The best ore ranges from 55 to 60 per cent. of iron, and shows only .005 of phosphorus and .06 of sulphur. In the lower workings there is a large proportion of good ore, but higher up there was about an equal proportion of low grade and high grade ores. Analyses of the ore have been made by Prof. Chapman, the Cambria Iron company, Booth & Garrett, and by the Troy Steel and Iron company. The analysis made by the last named company gave metallic iron 59.50 and phosphorus .005. We place the standard of shipping ore at 58 or 60 per cent. of iron, and have thrown out a great deal that did not come up to the standard. We shipped about 1,500 tons in 1881 and 1882, but have done nothing since then except about 100 tons last summer. The first named shipments were made to the Cambria Iron company. It was mixed with their own ore and the smelting was very satisfactory. We have now a contract with a large steel company which will use nearly all we can produce for a while. They will take from 500 to 1,000 tons a month if the ore will suit their mixture. There is a good market for our ores in the United States. Our ore is a freer working ore than those of northern Michigan, as it contains a greater proportion of lime, magnesia and aluminum. The Imperial mine is situated on lot 33, concession 3 of Snowdon, on the south side of Burnt river. It is about 400 feet long, 250 feet in breadth and about 60 feet high from the water level. It is a deposit of brown hematite. The general course of the wall is north-east and south-west. It occurs on the north in gneiss rock and on the south in a crystalline limestone formation. On the east side the land is low, sandy and

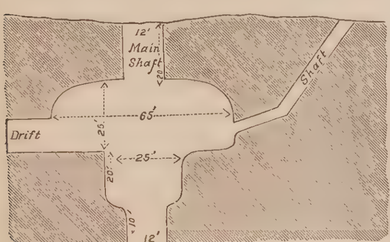


FIG. 20. Cross-section of Howland mine.

Railway construction.

Properties of the Toronto Iron company.

Howland mine.

Analyses.

Imperial location.

marshy, and the west side is a continuation of the range of hills. It appears to be a solid deposit. We have gone no depth into the hill, but have tried the surface in various places. We have had an analysis of the ore and it shows 45.82 of metallic iron. Phosphorus is very low, there is no sulphur or titanium, but a little lime and a large amount of silica. The analysis made by the Cambria company was of ore that would be considered a fair shipping sample. Prof. Chapman made an analysis of the poorer ore, so that we might see what its bad qualities were. It showed 36.17 per cent. of iron. The next property is beyond the railway as constructed, but is within a quarter of a mile of the line as it will be built. It is on lot 35, concession 4 of Glamorgan, and is known as the Pine Lake mine. It is a magnetic iron ore, and runs from about 52 to 55 per cent. It is low in phosphorus, but has a considerable amount of lime and titanium. A good deal of development work has been done on it. The deposit has been traced about 2,000 feet on the crested hill, and in some places the vein is 200 feet wide, but it will average about 100 feet. In the break in the hill where the vein is shown it is about 80 feet wide. It contains about 9 per cent. of titanium, and is practically valueless unless it can be used with our other ores for home manufacture; it would not do for shipment. An examination of the mine at Pine lake will satisfy anyone that it is not a pocket, and if that is not a pocket there will be other deposits of iron that are not pockets. We have never found it necessary to go more than five feet down to strike ore. The next is the National mine, lots 30 and 31 on concession 13 of Glamorgan. No development work has been done on it. The needle attractions show that it is greater in extent than even the Pine lake property. We have had no analysis of it. The next property is called the New York mine, and is situated on lot 27 in concession 15 of Glamorgan. It is the richest ore that can be found. At one point we sank a pit to get at the extent of the ore. We have traced it by the needle only, and we could follow it 400 feet in length and 30 feet in width. There is another occurrence on the same lot as shown by the needle, but there were no outcroppings and we have done no work on it. This ore was analysed by the Cambria company and Professor Chapman, and gives over 70 per cent. of iron, barely a trace of phosphorus, no sulphur and no titanium. It is about five miles from the proposed line of railway.

Pine lake location.

National location.

New York location.

James B. Campbell—I spend a good deal of my time at Kinmount and have been engaged examining timber limits and exploring a good deal within the last few years. I have prospected in Peterborough, Victoria, Haliburton, along the K. & P. railway and along the north shore a good deal. Altogether I have been about fifteen years in that business, but not constantly. I discovered the Snowdon mine and most of the deposits in that country, the Paxton mine, and Pusey's mine. There is one opening at the Snowdon mine of 40 feet, and another of 20 or 25 feet at the extreme north end. The 40 feet opening is about a quarter of a mile to the south. There has been some stripping between the two points. A considerable amount of ore was taken out, and there is a considerable quantity lying there yet. The Paxton mine is situated on lot 5 in the 5th and 5 in the 6th concession of Lutterworth and about 2½ miles above Kinmount. A considerable quantity of the ore was hauled 2½ miles to the railway and shipped; it has not been working for some time. The shaft is down about 20 feet. There is a considerable exposure in sight. Analyses by Professor Chapman show that it is a fine magnetite and to a great extent self-fluxing. The Pusey mine is composed of lots 26 and 27 in the 4th concession of Snowdon. There is one shaft down to a depth of 80 feet, and I am told there is ore all the way down. The vein is not largely exposed, but on the property there are surface croppings. It appears to be a large bed of magnetite. The largest deposits are supposed to be on Pine lake, about the boundary line between Glamorgan and Monmouth. There has been no work done there. One can see samples and stainings on the surface over an area of 100 acres. There is a deposit on lots 30 and 31 in the 12th of Glamorgan. I think it is a specular ore, but I do not know the analysis of it. On lot 34 in the 6th of Snowdon there is a little deposit of hematite. I know of a deposit near Haliburton, but cannot give the lot. I have seen a great many other deposits, but am only speaking of those I consider worth looking after. The Pine lake deposit is about 12 miles from the railway; the others are within about two miles of it.

Mining properties discovered.

John Stewart—I am a mining engineer and reside at Ottawa. I think, judging from the amount of development done in Hastings and on the line of the K. and P. railway, that there is no doubt about the permanence of iron mines in that region. I worked at the Wallbridge hematite mine. It was a large mass of ore in dolomite, with no defined walls. I think hematite is likely to occur again in that region.

The difficulty in exploring for it is that the needle will not lead to it; one has to spend time and money to find it. There were outcroppings on the surface at the Wallbridge. It had been worked in prehistoric times, but trees had overgrown the works. Tools were found there, deer horns, bone implements and such like. I found a human shin bone. In the Old Country I worked in the hematite mines in the Isle of Man. I visited about all the mines in Cumberland; they are in large masses. The ore does not occur in them like bog ore or brown hematite on the surface, but in the rock; it is soft and is mined with a pick.

The Wallbridge mine.

R. C. Clute—I am a barrister residing in Belleville and am interested in mining properties. I am interested in the lot immediately adjoining the Coe-hill mine. It is called the Station mine, and is composed of lots 17 and 18 in the 8th of Wollaston. I have the property in Marmora known as the Maloney mine; another in the township of Lake, known as the Mountain mine, composed of lots 15, 16, 17 and 18 in the 4th; another lot I think in the 2nd concession of Faraday; three locations in the 2nd concession of Wollaston, four miles south from Coe-hill; another in the township of Madoc, in the 5th concession, I think. All those deposits are magnetic. At the Station mine pits were sunk at different points with the object of ascertaining the surface extent of the mine. The width varies from 20 to 60 feet, and the length about 1,300 feet. The strike is about north-east and south-west. It has not been explored with a diamond drill. The ore has been analysed, and it shows a slight trace of sulphur, a slight trace of phosphorus, but no titanium. The analysis was made for Carnegie's establishment in Pittsburg, and my recollection is that the iron was 60 or 62 per cent. We did not send a large quantity, just a specimen.

Various locations in Hastings county.

The Station location.

Charles Taylor—Sometimes we get very good shows of copper and iron pyrites in the actinolite district. There is a large bed of iron pyrites in Hungerford, south of the Sheffield station. It is from four to six feet wide, and I think it extends over a large area. A pit has been sunk down 30 or 40 feet, and it can be shovelled out. A gold crusher was built upon it once, but there is only a show of gold.

Copper and Iron pyrites.

H. H. Wallbridge—I reside at Belleville. My sisters and sisters-in-law are interested in the old hematite mine and other mines near Madoc, but more particularly in a lot of 49 acres situated about two and one-half miles from the village of Madoc, being on lot 10 in the 6th of Madoc. It is between Madoc village and the hematite mine. About 100 tons have been quarried; work was begun about the time the mines shut down, and nothing has been done since. I think it is connected with Seymour's mine, and extends about 200 or 300 feet. It is about a mile and a half from the Seymour mine in a direct course. I think there is a large amount of ore, and we would be working it if there was a market. A good many thousand tons have been taken from the Sexsmith mine. It is less than three-quarters of a mile from the railway.

Wallbridge's mine.

The Sexsmith mine.

Leonard Wager—I think it must be about twenty years since I first noticed ore on my property at Tamworth. About 1878 I dug out some of the ore and examined it. After that the railway company put down four pits about ten feet deep. They cleaned out a pit 10 by 15 feet and the ore went down about three feet till it struck the white rock. On the surface it is about 10 feet wide, the ore dipping under the grey rock. Afterwards Mr. Rathbun set a few men to work for about three weeks. After that Mr. Broman, an experienced miner from Minnesota, did some work. He likes the ore and is prospecting still, but cannot yet say whether there is any large amount of it. Altogether about 25 tons of the ore has been taken out; it is a very good hematite. I can trace the ore on the surface for about 80 rods. I do not know of any other shows of ore about this section.

Shows of hematite ore at Tamworth.

Joseph Bawden—I have been connected with mining enterprises for at least twenty years in the county of Frontenac. I have been interested in both iron and phosphate properties. I have been connected with several companies engaged in actual mining operations—the Glendower, the Zanesville and Bedford companies. After some years spent in developing the property, the Glendower company was formed in 1873 and mining was continued by them for about seven years, during which time they took out some 12,000 tons of ore. The capital stock of the company was $50,000, and was altogether held by Americans. They worked the property in Bedford under a lease at a royalty, and at the end of the seven years they gave up the lease. The royalty was 20 cents a ton, in addition to which they paid a sum down at the commencement of the lease. Afterwards a company was formed by capitalists in Cleveland and Zanesville, Ohio, under the name of the Zanesville company and a branch railway was constructed to one of the mines formerly worked

The Glendower mining company.

The Zanesville company.

by the Glendower company. A large plant was erected and operations were carried on upon an extensive scale for four or five years. The Zanesville company was formed in the fall of 1882, I think, and was merged into the Kingston and Pembroke company in 1887. The capital of the Zanesville company was $200,000 paid up stock. I do not know the amount of ore that was taken out by it. Sulphur occurs in the mine at a depth of 120 or 130 feet, but none was noticed until that depth was reached. The Glendower company was composed of furnace owners at Elmira, N. Y. They took the ore there, and I have their testimony that they were well pleased with it, as were also the members of the Zanesville company. The ore ran better during the mining by the Glendower than during the time of the Zanesville company. I think the Glendower did not remove any less than 60 per cent.; the Zanesville company took as low as 50 per cent. The difference might of course be caused by selection. The ore during the Glendower company's time had to be hauled by wagon or sleigh to the Bedford station, a distance of some four miles, and that had something to do with their giving it up. When the Zanesville company commenced they had the railway brought into their mine, and it was shipped from Kingston to Cleveland. The Glendower company took it to Fairhaven. The Bedford mining company was organised last year and I am the manager. The capital stock is $250,000 all paid up. Sir Richard Cartwright is the president; I am manager and secretary. Our properties are altogether in Bedford; lots 7 to 11 inclusive in the 5th; the north half of 7 and the south half of 9 and lot 8 in the 4th; lots 2, 3, 4, and the west half of 7 in the 7th; lot 2 in the 6th; lot 1 and the west part of 3 in the 5th; part of 1 and all of 4 in the 4th; lot 2, the north half of 3, the south half of 5 and the east part of 6 in the 3rd; the north half of 2 and the south half of 5 in the 2nd. This makes altogether about 3,000 acres. We have prospected red hematite on 2 in the 7th, plumbago on 2 in the 6th, and also on 1 in the 5th; magnetic iron ore on 2 in the 3rd, and also on lot 8 in the 4th. We know of the existence of phosphate of lime on the west half of 7 in the 7th. We have had phosphate mined for us on the east part of 6 in the 3rd; also red hematite on 2 in the 7th. The accompanying rock is a crystalline limestone; it is on the border of Birch lake. The magnetic ore is found against crystalline limestone, with hornblende or granite on the other side. In one occurrence the hornblende is on the north and the crystalline limestone on the south. At Black lake we have the granite on the north side and I think crystalline limestone on the south side, but I cannot speak positively as to that as it is under water. The granite in Bedford is, I think, mostly on the north side. The course of the iron deposits is north-east and south-west. The width of the red hematite as far as traced is about 40 feet but I think it is a bed and extends further; I think it extends under the lake. We have traced it about 300 feet. It has never beeen tested. There is no titanium in it, but there may be some sulphur, as there generally is in the red hematite of this country; there is no phosphorus. The magnetic ores have been analysed. The ore from the Glendower mine runs all the way from 50 to 60 per cent.; the Glendower is just on the border of the Bedford property, and the ores on our property are I think equally as rich. The Black lake property was under prospecting lease (lot 8 in the 4th) to the Bethlehem mining company, and some 50 tons of very rich ore have been taken away. At the time it was under lease there were great difficulties in the way of transportation; since that time a canal has been cut from Thirty Island lake to Black lake, which will make it navigable all the way, and the ore can be brought down to the permanent track at Thirty Island lake. On the north half of 3 in the 3rd there has been some prospecting done, but a diamond drill has not yet been used. We purpose getting one at work there. Our ore in this section appears to be very rich. The year before last, for the first time in thirteen years' mining, they came upon sulphur in the ore, but we have not come across any on our property. On the red hematite property we have done some stripping and such work as that, but have not done any work of any commercial value. We know of the existence of iron in a north-east direction, in the 5th concession, on the same lead as the magnetite. On lot 2 in the 3rd, some 500 tons of ore were taken out before we got the property, but we have not done anything ourselves. The ore I take to be similar in character to the other ores in that formation. Our company was formed last year. Some prospecting has been done by it at Black lake, and the canal already mentioned was cut; it is 400 feet long, and lowered the water in Thirty Island lake; this was done to prepare for mining, but beyond that nothing has been done. Some prospecting has been done on 3 in the 3rd. We intend to put a diamond drill on 3 in the 3rd, and also at the Black lake mine. I am interested equally with Mr. Morris and Sir Richard Cartwright in a

Kingston and Pembroke company.

Bedford mining company.

Minerals on the company's property.

Occurrence of the iron ores.

Analyses of iron ores.

The Black lake location.

Prospecting work.

mine there on lots 12 in the 8th and 9th of Bathurst. It was first opened twenty years ago, and a quantity of ore taken out and sent to Cleveland, where it was tested by Chisholm, and reported upon favorably. The ore was a magnetite, and the deposit appears to traverse the length of the 8th concession from front to rear. About two years ago a shaft was sunk about 16 feet on the front of the concession, and two carloads of fine ore taken out. We traced the ore by showings at different points from rear to front of the concession, the direction being north-east and south-west. It occurs in a gneissoid rock. The limestone is to the south of it, and may have some relation to it.

A deposit in Bathurst township.

B. W. Folger—I am superintendent of the Kingston and Pembroke railway. I have been interested in iron and phosphate mining operations in this part of the country, but mostly iron. We are interested in perhaps 100 different mining locations. They are in Bedford, Portland, Hinchinbrooke, Oso, Olden, Palmerston, Levant, Bagot, Dalhousie, Bathurst and Sherbrooke We are interested in three mining companies—the Mississippi, the Levant and the Kingston and Pembroke companies. I am also interested in the Bedford company. The Mississippi company was organised about ten years ago. The capital, of which I cannot tell you the amount, was both American and Canadian. The Mississippi mine was opened up by that company, and between 30,000 and 40,000 tons were taken out; all the ore went to the States. The mine is not being worked now. The Levant company was organised about a year later. The location was leased to people in Bethlehem, Penn., who must have taken out about 30,000 tons. The Kingston and Pembroke company was organised about two years ago. The stock of that company is $4,000,000. I cannot tell you who are the principal shareholders, but they are mostly all Americans, seven-eigths of the stock is American. They are now working the Wilbur or Levant mine, and that is the only one they are now working. They have taken out of the Williams mine in Bagot perhaps 10,000 tons; it was a good steel ore. The low price of ore in the States, and the fact that the mine is five miles from the road, caused the stoppage of work. They worked the Wilbur last year as well as this year. About 12,000 tons has been shipped to Kingston and some of it is here yet. From the Calabogie mine they have taken out about 3,000 or 4,000 tons. From the Glendower they have shipped about 2,000 or 3,000 tons, and from the Mississippi about 2,000 tons. The ore shipped so far has been all Bessemer ore; it is magnetic. We have found hematite in a number of places, but never in quantities sufficient to ship. The iron shipped from here runs between 50 and 60 per cent. It is richer in some of the mines than in others, the richest we have shipped being from the Mississippi and Glendower. There have been no impurities in the ore from the Mississippi. Of late in the Glendower they found some sulphur, but none was found until at a depth of 180 feet. That was the reason they stopped work upon that mine. Since then they have put in drills, and have drilled about 300 or 400 feet, and got good ore again; where the sulphur was it ran from 1 to 3 per cent. There does not seem to be a large quantity with sulphur. We have not gone as deep as 180 feet in any of the other mines of that district. In the Wilbur we have gone down about 200 feet, and the ore from that mine runs about 55 per cent. iron. The Mississippi has no sulphur. At the Williams they are down about 100 feet. At present I do not suppose we have more than 60 men employed, but we have had as high during the year as 150. I cannot say what the proportion of miners would be. We pay from $1.25 to $1.75 per day now; the best miners $1.75, and laboring men $1.25. I think the Glendower alone would supply all that would be required for a 50 or 100 ton furnace, as it is in a position to take out 400 to 500 tons per day. At the depth of 200 feet the vein is from 20 to 40 feet wide, and what has been taken out averaged 60 per cent. It shows upon the surface for fully half a mile, and the foot and hanging walls are better defined as we get deeper down. The ore in the Levant ran in the first fifty feet up to 60 per cent., but lower down it is lower in iron. The rock is mostly crystalline limestone on one side and granite upon the other. If we could find red hematite in quantities, lake Superior could not compete with us at all.

Locations on the K. and P. railway.

Mining companies.

The K. and P. company's operations.

Capacity of the Glendower mine.

Michael Grady—I am a contractor and reside in Kingston. I came here at the time of building the K. and P. railway. They were then working the Glendower mine, and I commenced to look around and found several locations. Before coming here I had been in the iron districts in York state, which are partly in the Laurentian rocks. From the Glendower we can trace the ore for about a mile; there have been a dozen openings made in that distance, but I cannot say whether the ore continues all the way. There has been work done in four or five places, and quite a lot of ore has been taken out. The width of the ore exposed would be

Glendower mine.

about 20 feet. It was free from phosphorus and sulphur on the surface, but as they got down they found sulphur. That was the only case in which there was any trouble with sulphur. They claim that as they went down further the sulphur disappeared. Most of the ore there was mined by Rathbun of Elmira. I suppose about 75,000 tons were taken from the mine. The hanging wall was limestone, and the foot wall granite. At the Machar mine in the adjoining lot we did not go very deep—just shipped 1,000 tons from there. After that we sold out to another company and nothing has been done with it since. It was considered a pretty pure ore, and I think it went over 60 per cent. From the Wilbur mine about 50,000 or 60,000 tons was taken. The owners first sunk a large pit, but the ore dipped off at an angle of 45 degrees, and then narrowed; a good deal of money was spent following it, but finally work was stopped at a depth of about 100 feet. Since then one of the owners has died, and nothing more has been done except some exploring with a diamond drill, and they claim to have tapped the ore again within 100 feet of where it was mined out. It widened out at one place to 30 or 40 feet and then narrowed to 3 or 4 feet. It is stated to have been the finest ore for shipping ever got in this part of the country. I have seen analyses that went over 68 per cent., but of course that would be of picked specimens. I have been told that it was sold on a guarantee of 65 per cent. We never found any titanium in that section; there is none in the Wilbur deposit. The deposit is in granite and white limestone. About 1,000 feet above the old Wilbur are two shafts on the same lode. One of these is down about 200 feet, and the other about 180 feet. They have taken altogether from that mine about 100,000 tons. Only one shaft is being worked now, but they say it is not looking as well as it was before. We find some soapstone on the foot wall; on the hanging wall it is principally limestone. In the Wilson mine we are down about 50 or 60 feet; it can be traced 500 or 600 feet; three or four openings have been made in that distance and about 4,000 or 5,000 tons taken out. The ore is very good; I think it runs about 60 per cent. It is very free from sulphur and phosphorus, and occurs with granite on both sides. At the depth of 50 or 60 feet the width was about 9 feet. In the Williams mine we opened about 300 feet along the course, and took out about 10,000 tons; we went down about 15 or 20 feet. The vein seemed to be 7 or 8 feet wide, and they say it pinched out some as they went down deeper. South of that point the rocks seem to dip south-east, but here they turn over and dip the other way. The foot wall is limestone, and the hanging wall granite. The ore ran about 52 or 53 per cent. as they shipped it. I never heard that there was any sulphur in the ore. These are about the only places where we did work of any account. Mining when done by contract costs about a dollar a ton; when done by the day's work it costs about $1.25 a ton.

Machar mine.

Wilbur mine.

Wilson location.

Williams location.

Cost of mining.

J. S. Campbell—I reside at Perth and am interested in mining at Calabogie. I am president of the Calabogie Mining Co., organised in 1882; the principal shareholders are Edward Elliot, William Hicks and Peter McLaren of Perth, Hugh Ryan of Toronto, and B. W. Folger of Kingston. About $75,000 of the capital is paid up. We own the east half of 16 in the 11th of Bagot, on Calabogie lake, the west half of 16 in the 9th, 14 in the 7th, and the south half of 16 in the 8th. Altogether we have 600 acres. The property at the lake was developed by Ely of Marquette in 1881. We commenced work in September 1882. The first shaft was about 100 feet down, at an angle of 30 degrees; the width is from 8 to 20 feet. It was abandoned in 1883, and in 1886 we continued the shaft 108 feet further. It was mixed with rock less or more. The second opening towards the east we made two years ago. We went down 30 feet there, and in that depth we went through 8 feet of iron. We leased to the Kingston and Pembroke company then, and they worked the next year. In the new shaft they drifted about 75 feet. Where they were working the width of the vein was from 10 to 12 feet. There has been a considerable amount of iron taken out of the hill. We shipped about 1,000 tons from Kingston. Last year the K. and P. Co. shipped about 2,000 tons from the same place. It was sold at Cleveland and was a satisfactory Bessemer ore. The mine on lot 16 in the 8th was opened in the fall of 1883, and sank 45 feet; no drifting has been done. We had iron all the way down at a width of from 10 to 12 feet. The iron was analysed and the first showed too much phosphorus, but in the last the amount was reduced considerably. There was no sulphur of any consequence. We employed from 20 to 25 men, and miners were paid $1.50 a day, laborers $1.25. We had a 25 h.p. engine, and used steam power for drilling and hoisting. We only operated one steam drill. The value of the plant would be about $5,000. On lot 16 in the 8th we did not have any steam power; there the ore was hoisted by horse power. We made a surface opening on the west half of 16 in the 9th in 1882.

Various locations in Bagot.

The Calabogie mine.

Other locations opened.

The range is the same as 16 in the 8th, and the ore is very similar; the opening was about 10 feet. This range can be traced a distance of two miles to the lake; it is on the same range as the Calabogie property. The general course is a little south of west; the dip is about 30 degrees at the lake. On the south half of lot 16 in the 10th of Bagot, which is upon the same range, some prospecting has been done.

W. J Morris—All our minerals, as far as I know, are confined to the Laurentian formation. The rocks in Bathurst are saccharine limestone and gneiss. Magnetic iron ore of very high grade occurs in the 8th of Bathurst; speaking from memory, I think there is limestone on one side and the other wall is gneiss. Several carloads of this ore were sent to Cleveland, Ohio, and they said it was the finest ore they had handled, but no contract could be entered into on account of the want of communication. The range extends north-east and south-west for a distance of five miles or more, and the width for that distance is about three-quarters of a mile. I do not mean to say that there is solid ore all that distance. Several years ago Alexander Cowan took out several thousand tons on the same strike in North Crosby. I think that not less than 3,000 tons were shipped. It was sent to the States; that was in the time of the American war. Except what Mr. Cowan did, no work has been done on it to any extent. I think that is about eight miles from the point I was speaking of in Bathurst. Mr. Cowan sold to an American company; they got out of the ore, drifted and struck it again, but at the close of the war the price fell, and as there was so much hauling the ore could not stand it. It was known as the Fournier mine. They went down about 100 feet altogether, and the ore was beautiful and solid. The veins are from three to seven feet wide. and evidently widen as they go down. Where we made some openings the ore was very fine. There was no sulphur, but it was cut in one or two places by veins of apatite; the apatite was not mixed with the ore. At Bobb's lake. on the McMartin property, there is magnetic ore. When I saw it the whole country was covered with bush. My idea, however, was that there was in all probability a large deposit there. Surface specimens were to be found for a long distance, and of very good quality. It is a very rough country, and I did not examine its occurrence except to see that it is in gneiss. I do not remember that I noticed any crystalline limestone. The rock associated with the phosphate at Bobb's lake is pyroxene. There are great nodules imbedded in it that are apt to roll down on the men. I cannot state what the chemical composition of the nodules is; it appeared to be hornblendic rock, but in a state of disintegration. In Levant and Darling there are large surface showings of magnetic ore. Dr. Wilson and my father bought lands there seventy years ago for the sake of the ores. Sir William Logan estimated that there was a bed eighty feet thick on Christie's lake, in the township of South Sherbrooke, but I think that is a mistake. It is a parallel deposit to that on the 8th concession of Bathurst, has the same strike, and is ten miles to the west. There are extensive showings in the south-west corner of Darling, in Levant, in South Sherbrooke and in Bathurst of magnetic iron, and the strike is the same all the way through. They generally occur in gneiss; there is generally limestone in proximity, but not in actual contact. We have bog ores in Ramsay and Drummond. There is plenty of good magnetic ore in this district. In Levant there is sulphur in some of the veins, but there is a good deal of the ore that is free from it, and it can be cobbed. In Bathurst the ore is high grade, and I do not know that there is sulphur; the only thing I would fear is that the veins would not turn out as large as in other parts where the ore does not grade as high. I have not seen it more than five or six feet in width. I do not think veins of that high grade ore will average more than five or six feet on the surface. The largest deposit of hematite is the well known Playfair mine, from which a good many thousand tons of ore were shipped to Cleveland as long ago as twenty years. I think they shipped as much as 3,000 or 4,000 tons a year for several years. Torrance of Montreal and others were the owners. I do not think they worked it below eighty feet, and I think the average width of the solid hematite was fifteen feet. It widened to that; on the surface it was about five feet. The shaft was simply an open pit. The deposit was not followed upon the surface for any distance; it was only worked on part of one lot. It was very soft on the surface, and became very hard as they went down. I think the wall was diorite upon one side, and that it was capped with crystalline limestone. There are two or three small veins, and parallel veins in close proximity. There are also parallel veins two miles southward, which never have been opened. The property was leased for ninety-nine years. There is a vein of hematite in Arnprior which I think has the same strike. The belt bearing the hematite is fully three miles wide, and we can trace it across the river into Quebec. I think that there

Magnetic ore Bathurst.

The Fournier mine in North Crosby.

Bobb's lake location.

Deposits in Levant, Darling, Sherbrooke and Bathurst.

The Playfair mine.

are deposits of hematite across McNab, Packenham, Darling, Dalhousie, Bathurst, South Sherbrooke and Crosby. The belt is three miles wide; that is to say, for that width we find surface indications. It is a very rough country, and has never been properly explored by anyone. I know at least two ranges of hematite. I think about thirty years ago several hundred tons were mined at Sandpoint, and I am satisfied that is on the same strike as Bell's property. My opinion is that that goes through the west corner of Bathurst, where there are extensive superficial showings. That range has never been properly explored. I have seen veins at low water on both sides of Bennet's lake. There are indications of specular ore through North Burgess and the west half of North Elmsley for a distance of ten miles. No vein or bed of ore has ever been struck, but it must occur. The rocks there are more disturbed than in any place in Ontario, and I think it is the only place in Canada where you can find silicate of magnesia (meerschaum), but too thin to be of any value. This section of the country has undergone great volcanic action, and the formation is extraordinary. There is iron pyrites in Dalhousie, in the vicinity of Mr. Browning's place. I think it is both nickel and copper bearing; it runs across three 200-acre lots, and will average 150 feet wide. It is a magnetic pyrrohtite and not common pyrites; it decomposes very rapidly. I think it goes down a considerable depth. There is diorite on one side, but I do not know what to call the rock on the other. I was told it contained a certain amount of nickel, and, unless I am mistaken, forty per cent. sulphur; it is very dark in color. There are many other deposits of iron pyrites in South Sherbrooke and the north-west part of Bathurst.

A hematite belt.

A very disturbed locality.

Iron pyrites in Dalhousie.

William Rattle—I live at Cleveland, Ohio, and am a mining engineer and analytical chemist. I have had considerable experience with ranges in the Huronian formation. So far as my observation goes in the Laurentian rocks the strike would be north-east and south-west, the dip south-east. In the first range we visited near Perth, in Darling, the accompanying rocks were on the foot wall diorite; on the hanging wall it would be difficult to tell as no work has been done, but I think it is crystalline limestone. There are some black slates on the south. The ore is a hematite; it is more in the nature of a specular iron ore. At Playfairville there is a surface showing of red hematite; we find some slate and some diorite upon the foot wall and granite under that. The magnetic is the second range; the hematite would be the north range. The lower range cuts the crystalline limestone, and I cannot say what the walls are outside of the limestone. It is almost perpendicular in the lower range. South of that we found hornblendic schist. The limestone appears to be a capping over the whole country; I think it is of volcanic origin; it is a metamorphosed rock. It is not at all similar to the northern Michigan ranges; those are much older. I think that the capping of limestone here is later than the deposition of the iron. I am very well satisfied with the outlook in this country; I judge the ores to be of good quality, as far as one can tell by looking at them. I think the prospects are such as would justify reasonable development. That applies both to magnetite and hematite ores. There are five distinct hematite ranges. They are not of the soft hematite nature, but of the red specular. We were on three magnetite ranges, one of which had a great deal of sulphur, the others had not. The sulphur in some cases here occurs all through the mass, which is so close grained that the gases cannot get away. In Norway the ores are of a spongy nature, and the sulphur occurs in cubes in the spongy mass, so that the sulphur is enabled to escape.

Strike and dip of the Laurentian rocks.

Ore in Darling township.

Ranges of iron-bearing rocks.

Joshua Gallagher—I live in the township of Bathurst, in Lanark, and am a miner by occupation. I worked in the Playfair mine upwards of three years. This property is situated on the east half of lot 1, in the 4th concession of Dalhousie. The mine was worked for five years. The ore is a red specular and was considered a No. 1 Bessemer steel ore. In addition to the surface work, five shafts were sunk on the deposit. No 1 shaft was sunk to a depth of 70 feet. The ore on the surface was about 3 feet wide, while at the bottem of the shaft it was 8 feet wide. No. 2 shaft was located 200 feet from No. 1. The ore on the surface was 2 feet wide. The shaft was 75 feet deep and the ore at the bottom was 15 feet wide. No. 3 shaft was located 150 feet from No. 2. It was sunk to a depth of 50 feet and by drifting showed ore 40 feet wide. No. 4 shaft (150 feet from No. 3) was not sunk so deep, surface exploration being made owing to its situation not being convenient for using machinery. The ore was hoisted from No. 3. No. 5 shaft was situated about 150 feet from No. 4. Surface exploration to a depth of 120 feet was made. This shaft was capped with granite to a depth of 14 feet. All of the shafts contained specular ore of Bessemer quality, being almost entirely free from phosphorus.

Working the Playfair mine.

sulphur and titanium. At the bottom of No. 5, when work was stopped, the ore was 30 feet wide. The ore from the different shafts shipped analysed from 65 to 63 per cent, and was principally sold in Cleveland. The foot wall was composed of crystalline limestone and the hanging wall of granite. The run of the ore was in a north-westerly direction. Most of the ore was drawn to Perth during the winter months by teams, the distance being about 15 miles, each team making one trip a day and averaging four tons per load; the road being a very level one this quantity was taken with ease by the teams. The ore was shipped from Perth to Brockville by rail and thence by water to Cleveland. The cost of drawing to Perth was $1.10 per ton. Operations began at this mine in 1867 by Alexander Cowan of Montreal and were continued for five years. I cannot say why the work was stopped. The original owner of the property was J. J. Playfair, who I think lived on the lot at one time. While the mine was being worked from 15 to 25 men were employed. A large amount of ore was shipped from the mine each year, but I cannot say how many tons. I always understood this ore gave entire satisfaction at the smelting works.

Quality of the ore.

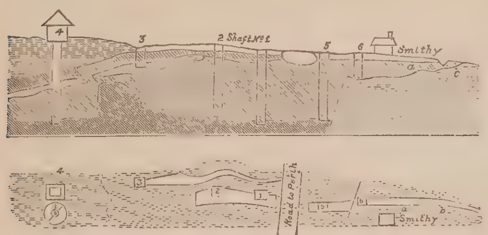


FIG. 21. Longitudinal section and plan of Playfair mine. Scale—600 feet to an inch.

1, 2, 3, 4, 5 and 6, numbers of shafts.

R. C. Sherrett—I have been interested in mineral development for about nineteen years. During the whole of that time I have been at it more or less constantly. In Dalhousie there is a very large deposit of iron pyrites; it seems to be one mass. I don't know how many acres it would cover, but I should say there are very many thousand tons in sight. A little has been blasted and broken but there has been no shaft put down. It looks like ordinary iron pyrites, but after exposure it takes a yellow brassy appearance. I think it is magnetic iron pyrites, but I have never held a needle over it. I thought at one time of trying it for copper; it appears to carry a percentage of copper. There is very little rock in it; it appears to be about 80 or 90 per cent. pyrites. It is about 400 or 500 feet one way and 200 or 300 feet the other. I am satisfied it goes a good deal further than that. It is about 22 miles from Perth. I was at the Playfair mine when it was working. There was a great deal of ore taken out, I think about 16,000 tons altogether. The vein varied very much in width; at times it would be over 20 feet and again it would be down to 2 or 3 feet within a short distance. I think it was a lense of ore and that there are several other lenses on the same range north and close to it. I have noticed three deposits of hematite, but I cannot say whether in the 3rd or 4th concession; they are near the Playfair mine. Those I saw were covered, except in places where they had been opened by some one. I am satisfied they are parts of a large deposit below. The Playfair occurs in limestone on both sides, and the others occur in the same character of rocks. I have no doubt hematite could be found to the north of the Playfair, but I do not know about the south. There are a good many deposits of hematite to the north of us here, but it would require a diamond drill to determine their value. I have seen some deposits at Palmerston, but there has been nothing done at all and I cannot say anything about them. I think the crystalline limestone is intimately associated with the hematite ore. The band that is associated with the hematite is highly crystalline and coarse. In Palmerston, where there is hematite, the rocks have something the character of

Iron pyrites in Dalhousie.

The Playfair mine.

FIG. 22. Playfair mine, showing cross-sections. Scale—600 feet to an inch.

1, 2, 3, 4 and 6, numbers of shafts.

On Adam's lake. Indications in Darling. Hematite in Leeds. Magnetic ore.

dolomite. It is a different kind of limestone from the Playfair altogether. I saw very little except what occurred in the bush and I did not disturb it; I took out some 60 pounds. There is some hematite near the Rideau on Adam's lake, in north Burgess, and some work has been done on it. It is not a very large deposit; it would perhaps average three feet at the outside, but it is continuous. On Caldwell's property in Darling they had indications of a great deposit, but when they opened up they did not find it; they may find it yet as there is hematite there in several places. I have seen good indications in Darling, but there are no large deposits open. I think large deposits will be found on Mr. Bell's property at White lake. At Charleston lake, in the county of Leeds, there is hematite. The deposit is 15 or 16 feet wide and is rich. I have seen a piece that was taken out and analysed something about 70 per cent. The lot belongs to the government and has been covered with water. Some 300 or 400 tons of it have been taken up and crushed for pigment by Mr. Ramsay. There is some hematite also on Dog lake, near Kingston. It is in the silurian limestone and is lean ore. That is all the hematite I know of. The Playfair appears to be the most workable location; there is quantity and quality, and there has been development to a considerable extent; the main shaft is down about 100 or 120 feet. On the 8th of Bathurst there is magnetic ore on several properties. The ore occurs in very irregular form; it is not continuous and 12 feet is about the greatest width. It occurs on five different lots, and in each case with granite on both sides. It contains very little sulphur. There has been so little development done that it is not possible to say anything as to the quantity. I do not think there ought to be any trouble about getting a large supply of magnetic ore, and I think a considerable amount of hematite could be got from the Playfair. If there were a demand I think plenty of ore would be found. There is a large quantity of the ore that carries sulphur as high as $2\frac{1}{2}$ per cent.; that would have to be calcined before smelting. The magnetic ores that I have seen are in Palmerston and are undeveloped.

Iron ores in Levant township.

William Caldwell.—I am a lumberman and am also interested in mining deposits in the county of Lanark, township of Levant. We can trace the surface shows in one lead cropping up here and there, the width of which is about 300 feet; that is with the rock, then ore and rock again. The ore is a magnetite, and an analysis shows 61 per cent. iron, no phosphorus and no titanium. In the largest deposit, which crosses the K. & P. railway and is about half a mile from our station, there is 2 per cent. of sulphur. The strike is about north-east. We have quite a number of shows with the needle, perhaps half a dozen altogether. The other deposits appear to be free from sulphur, and as high in iron as the first mentioned; they do not look like titanium ores. I cannot tell you the character of the rock associated with the large deposit; there is crystalline limestone in places, and farther south there is some diorite.

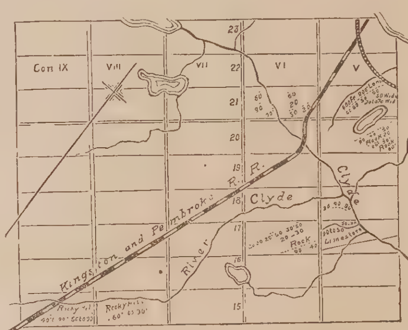


Fig. 23. Sketch of Caldwell's location.

I am satisfied there is a considerable amount of iron in this country. Take the townships of Levant, Darling and Bagot and one cannot go on any hundred acres without finding a strong attraction of the needle.

A prospector's opinion.

Thomas Royce—I have been engaged in prospecting, of which I have done a good deal. I discovered Mr. Coe's Calabogie property. I have discovered a number of other properties that we have not secured yet. They are in Darling, Bagot and Packenham. I am satisfied there is plenty of hematite ore and that it is of good quality; all that is wanted is development.

Specular ore in Darling.

W. H. Wylie—I am interested with other parties in iron properties in the township of Darling. On the east half of 16 in the 4th we have specular ore. We have made no development more than sinking two or three pits. The ore occurs on a hill which runs down to a marsh. I cannot tell the extent of the deposit, but it seems to be a mass of ore; we traced it quite a distance, perhaps for 200 or 300

yards. We got specimens in the gravel of the hill for a width of 150 feet, but I do not say the deposit is that wide. The principal opening is at the foot of the hill. It has not been stripped to any distance, only a few days' work having been done. The show was so good that we did not think it necessary to do any more at present, as there is no market. An analysis made by Dr. Ricketts of New York shows 66 per cent. iron, .036 phosphorus and no titanium. The general course of the deposit is north-east and south-west; that is the course of the formation generally. It seems to dip at an angle of about 40°. I cannot tell you the width of the deposit. We have magnetic ore in Darling, on the east half of 22 in the 3rd, and the east halves of 21 and 22 in the 4th. We have done some development on one or two lots, on the east half of 21 and 22 particularly. In one place we went eight or nine feet and took out a couple of cars of ore. It would average about 60 per cent.; any we got assayed showed 65 per cent. The deposit seems to be very considerable. We got it right across all those lots, but never more than four feet wide. It contains no phosphorus and very little sulphur. The analysis shows iron 65.33, and phosphorus .017. There is limestone on one side and diorite upon the other, or hornblende rocks of some kind. The iron formation would be about half the width of our lots, I should say. North-west of the iron we have copper rocks, where there is a gully, and the formation changes. In the township of Levant we have several lots with iron on the 1st and 2nd concessions. That was discovered in 1881 and some development work has been done; there is a pit 20 or 30 feet wide and 6 feet deep. Iron ore was found all over the bottom of the pit; as far as we could judge with the needle the vein was from 50 to 60 feet wide. I have been told that it has been traced for about a mile, but I have not traced it myself. The strike is north-east and south-west. The surrounding rocks are hornblende; I do not know of any limestone. We never shipped any of the ore. At that time we had no roads, but there is a road now built to the station, four miles distant. Mr. Birkinbine, the engineer, classed it as a good Bessemer ore. He did not think it would require to be calcined. Bog iron occurs in low ground in the township of Goulbourne. There is a vein on the same property containing pyrites. I also own an iron pyrites property on lot 5 in the 4th concession of Darling. It was opened up a little before we got it; the man on the next property had gone down 7 or 8 feet; the vein was full of quartz and ochre. The rock on one side is crystalline limestone and on the other diorite. I think it is a true vein; it seems to go straight down. The vein matter stands out from the rock; it is about eight feet wide at the top, and it widens out to about 10 or 12 feet at the bottom of the pit, which is now down about 35 feet. It has been traced fully a mile I believe. The analysis for sulphur showed 55 per cent. sulphur and only a trace of gold and silver. The party from whom we got it had specimens from the surface which he reported as giving $9 gold and $3.50 silver. I should think two-thirds of the whole vein matter is pyrites. Perhaps one-half of the vein is pure pyrites, and would do to make sulphuric acid; the pyrites is not magnetic.

Magnetic ore.

In Levant.

Bog iron ore.

Iron pyrites.

C. Clymo—In Darling I worked at an iron pyrites vein for Mr. Wylie. The vein is three or four feet wide. We took out some very large specimens; it is all through the vein. We can trace it for 1,000 yards; it is capped over in places, but I think it is straight all the way. We went down 35 feet, and it looked as good in the bottom as above. I think it dips a little to the south. I would take a contract to get the pyrites out of that vein at from $1.50 to $1.75 a ton.

Iron pyrites in Darling.

James Bell—I reside at Arnprior. I am a general agent and have been interested in mining operations for sixteen years, particularly in iron properties. I own properties in the townships of Darling and McNab. In McNab the property is lot 6 in the 13th. It is about three-quarters of a mile west from Arnprior and is generally known as the McNab mine. It was opened 16 or 17 years ago and was worked at that time by the Peter Bell Iron Co. of Boston, through their agent, J. P. Mansfield. They worked it about a year and took out about 10,000 or 15,000 tons. They stopped working because of trouble among themselves. Work was resumed, and it was found that the ore diminished in quantity; there was a fault and they would not go to the trouble of drifting. An Ohio company put on a few men to catch the lead about 60 feet from the opening first made, right opposite the railway track, and went down about 60 feet. They said there was considerable ore, but the water came in and they had no proper pump. Besides, just then there was a great fall in the price of ore, and it was a long way to take it from here to Cleveland, so they dropped it. It lay for a number of years till finally it was divided into lots, and I purchased them. At the time I acquired the property the original shaft was full of water. I commenced to make openings on

The McNab mine.

the vein, went down about 10 feet in each place and took out about 300 tons. After that I did not do anything further with the property. I worked part of one summer, in 1883. The iron appears to occur in magnesian limestone. The same occurrence can be traced for five or six miles on the same course, the indications being the same. The ore from the mine here is hematite. It went 68 per cent. iron; there was a small particle of phosphorus, but no titanium or sulphur. Mr. Wallace of the Ohio company said it was the best ore they ever handled. On the mine here there was a capping of crystalline limestone; magnesian limestone is exposed for about 40 feet, and then disappears under the crystalline limestone on the north-west side. I have other property in Darling composed of about 1,000 acres. The iron there is red hematite and was first discovered about 25 years ago. No mining has been done beyond the prospecting of openings. I have also an interest in an iron property in Montague, county of Lanark, about 1,000 acres; there is bog ore on that property. I took out about 800 or 1,000 tons of the bog ore; some of it was sold in the United States and was smelted there, and they told me at the furnace it turned out 51 per cent. The country there is full of springs, and the ore is always found where there has been a flowing spring. I think there was some manganese in the iron. I have bog ore also at Beverage's lake, on the lower Rideau lake; it is not more than four feet deep. A man to whom I gave a contract took out 180 tons, and that was sold in Montreal. It was exactly like the other ore.

Red hematite ore in Darling.

Bog iron locations.

W. T. Newman—During the last two or three years I have been prospecting in the Nipissing district, particularly around lake Nipissing. There is iron on Great Manitou island, 20 miles from North Bay. On the same location magnetite, hematite and limestone are found. There is no limestone for hundreds of miles in that country except what is on that island. From the fact that the compass will not work at all I judge there is a great deal of ore. The hematite is in situ and the magnetite in boulders. The property is densely wooded. I believe it is on the same range as Iron island. On Iron island iron occurs in great loose pieces on the shore. The only trace of a vein I saw there after considerable investigation was about three inches wide. I have examined the occurrence on Manitou island and Newman island, my own properties. The rocks are limestone and sandstone. I cannot tell you the rock the ore occurs in. I never saw such rocks elsewhere; there are great pieces of hornblende in the formation. It is different from anything I ever saw. It is a reddish crystalline rock; that on the south is bounded by limestone. Hematite and magnetite occur together on the south shore of lake Nipissing, about three miles from the Northern railway, in the township of Nipissing. Altogether I have discovered eight different deposits of iron ore, six of which I am satisfied are in quantity, three magnetite and three hematite. These six are workable and vary in width from two to four feet.

Iron deposits in lake Nipissing.

Hematite and magnetite ores.

E. V. Wright—There is iron all through the lake Temiscaming country and in large quantities, both magnetic and specular. There is also a great deal of micaceous iron through that country. I did not find any red hematite. I think the magnetic ore is the most plentiful. I have not taken out any specimens or made any analysis of it. There is a fine magnetic ore a little south of the Ontario and Quebec boundary line, at the head of the lake, and the Indians told us it was six miles in width. The way we came to notice it was on account of all the trees having been struck with lightning. It is at Quinze river, at the head of the lake. I have not seen specular ore in large bodies except in one place on the side of the Montreal river. I have not heard of the occurence of red hematite in that section. I got two specimens from the Indians, but I don't know where they came from.

Ore deposits in the Temiscaming region.

Henry Ranger—I have not seen any iron ore of any consequence in the Sudbury district, but I found a large deposit of iron pyrites in the township of Graham. It shows to be about 150 feet wide, and I think it is solid pyrites. It is bright yellow, something like copper pyrites; I traced it for about 300 yards. It is on lot 12 in the 3rd of Graham.

Iron pyrites in Graham township.

Thomas Frood—Back from lake Huron, on the Wallace mine location, is a deposit of iron; it is on the side of the mountain. A shaft has been sunk there to the depth of about 20 feet. That shaft was cleaned out this spring by a Cornish miner whom I employed for the purpose. The iron is on the rear of the property, north-east from the old Wallace mine. The property as originally patented consisted of 2,200 acres, and the Hughes Bros. of Toronto and myself now control 1,600 acres of it. It is on this 1,600 acres that all the work has been done. I cannot exactly say how the iron should be classified. It is of steel color, slightly magnetic; part of it is

Wallace mine location.

red and very soft. The vein is visible for about 200 yards; at the west end on the surface it is about six inches wide; at the east end, where the pit has been sunk, the width of the vein is about 8 feet. The depth of the pit is about 20 feet and the vein seems to increase in width, and the ore to improve in quality as we go down. There have been no assays made since we have had possession of the property.

Henry S. Hedges—One of three deposits of hematite iron which I discovered near the Wallace mine location I believe will last for three generations if worked. It is an enormous mass of ore. The hematite and magnetite beds discovered by me are quite close together on the same property; it crops out all over some 10 or 15 acres It is on high land, near the water, and is handy for shipping. I had to sell part of this property so as to be able to retain part.

Hematite and magnetic iron ore deposits.

James Stobie—I opened up and worked the iron mine at Desert lake, in the township of Coffin, for some years. I opened it up in 1874, and worked it three or four years. We formed a stock company, but iron fell and we never worked under the charter. The width of the vein was from two to eleven feet. It was hill-like, and the greatest height of ore above the surrounding country was 50 feet. We drove two adits. It was an outcrop and we could trace the ore through the centre of the bluff for a couple of miles. We had 160 acres, and there was an adjoining location taken up by E. B. Barton; it was hematite. I cannot tell you the number of tons we shipped to Detroit, but there were several vessel loads; we shipped three seasons, and used to haul to the water during the winter. The location is ten miles north-west of the Bruce mines. The principal owners live in Detroit. There is no better ore anywhere than that is; it is free from sulphur, titanium and phosphorus, as far as I know. No work has been done since the time I worked it. I think if we had continued we would have found the greatest quantity of ore in the low ground. Part of it was soft hematite. Had work continued it was our intention, if we found a large quantity of ore, to smelt it right there. I think our deposit would prove to be a permanent vein; it did not appear to be in pockets. The Lacloche mountain country is very similar to the country at Desert lake. In the region from Killarney to the Sault we find iron between quartzite and diorite; the quality is very good there and important discoveries will, I think, yet be made there. There is no good iron ore in the Sudbury region that I have seen; it has too much sulphur, but I have found boulders at Sudbury and farther north with good ore.

Desert lake location.

The Lacloche mountain country.

The Sudbury region.

William Plummer—I have examined an iron deposit at Desert lake; it is in quite large veins or beds, and occurs in quartzite. I am speaking of the location that was worked by Mr. Stobie. The ore was of very good quality, but he had not the means to work it. There are at Missisauga three or four mining locations. I examined them twenty-five years ago, and nothing has been done with them since.

Desert lake and other locations.

R. E. Bailey—We have an iron property near Echo lake, about three-and-a-half miles north-east of the point where the river enters into the lake. We have uncovered the iron in six or seven places and found it of good quality for a width of 15 or 20 feet; we traced it for about 1,400 feet. It seems to run east and west, but I am not positive as to that. I cannot say whether it is a vein or a bed. We have had the ore analysed, and it shows 65 per cent.; it is very free from posphorus and sulphur. There is a very large quantity of the ore, and it is handy for shipping, being about three miles from the river and only nine miles from the Canadian Pacific railway. I cannot say what the country rock is as I did not examine it; I was only on the ground a few minutes. I have heard of several other iron locations around there which are said to be good.

Iron properties near Echo lake.

P. C. Campbell—I have the option, from a Milwaukee company, of an iron deposit north from Echo lake; it is about three miles north-east of the lake. I dug a trench in the gossan covering it for some 50 feet; we traced it some 400 feet and found it was capped by a bluff of the country rock; we examined further and discovered it again beyond the bluff. The ore is hematite, there being 66 per cent. metallic iron; it is a very pure ore, and so soft that one can dig it with a spade.

Alex. Sawyer—I have done some exploring in the Algoma district, and have found an iron mine in or near Macdonald township. I ran across some others, but they were located. The deposit is about fifteen inches wide where it shows. I followed in the direction I thought it would lead, and found it again at the end of forty acres. The ore is very pure and heavy. I do not think it is exactly in Mac-

On the Garden River reserve.

donald; it is in what was the old Indian reserve. It is about three-quarters of a mile from Bailey's location—to the north-east. I had to get money from Mr. Plummer to secure the location, and had to give him an interest in it to do so.

Deposits on Loon and Ruby lakes.

William Murdoch—I have sold an interest I had in a very large iron deposit near Loon lake. Mr. Coste of the geological survey says there is a million tons of ore in sight. On Ruby lake there is a deposit of very good hematite that will go 65 per cent.

Surveys of iron locations west of Port Arthur.

William Russell—We had many locations to survey this year, particularly in the iron region west. We will survey this year, counting what is now in progress, perhaps seventy locations, the majority being iron locations. Beginning about the head of Cypress lake, south-west to Carp lake, a distance of about 14 miles, we have surveyed between thirty-five and forty locations, the total area of which would be about 4,000 acres. The surveys were almost invariably made for American capitalists. On all these locations, with one exception, there is iron to be seen. The ore is in general red hematite, but some of it is magnetic. It occurs in connection with jasper. These beds of ore are veins from 10 and 20 to 150 feet in width. In the Tower region none exceed 200 feet, and the average would be about the same as ours. I found a vein in which iron occurs with silicious matter, 100 feet wide; the surrounding rock was green slate.

Magnetic and hematite ores in the lake Superior district.

Thomas Hooper—From what I see in the lake Superior country the iron outlook is very promising. I have seen many good specimens of ore from this district. I have seen A 1 magnetic ore that would go 60 to 70 per cent.; that was from very near the boundary line. I have seen some hard hematite of very fair quality, and I have seen some that carried titanium. The specimens that I saw from both sides of the line were very similar. I have had a good deal of experience with iron, and have shipped a great many thousand tons.

Surveying iron locations.

Ore on Hunter's island.

William Margach—Last season I travelled along the national boundary; I was examining that country to ascertain what amount of timber had been destroyed by fire. At the head waters of the Pigeon river I observed here and there large quantities of iron. I found a survey party laying out a location for iron on South lake, also on Gun Flint lake, and on Hunter's island. Fifty miles further west I found two parties of surveyors, one on the American and one on the Canadian side. I found dozens of parties, principally of Americans, exploring for iron. I showed the Tower miners some specimens that I got from the surveyors, and they mixed them up with their own and could not pick them out afterwards. It seemed to be the same color as theirs—a red hematite. Since then thousands of acres of iron land have been taken up on Hunter's island, and parties are still surveying. Hunter's island is about 60 miles long and from 15 to 20 wide. It is a very rocky country; there has been timber, but it has been burned over; there is still some good pine there, but I cannot say how much. The whole of the island seems to be mineral bearing, but the indications on the south are better than on the north. From the lower end of South lake to the upper end of Gunflint lake, a distance of twelve miles, it seems to be all hematite iron. We also know from the water that there is magnetic iron. Immediately across the border from Gunflint lake the Americans have put in a diamond drill, resulting in their finding iron to the depth of forty feet; they got through it at that depth. Gunflint lake is 70 or 80 miles from Port Arthur, and from that on to Basswood lake is iron formation.

A large area of hematite ore.

Iron ores in the lake Superior district.

The Atik-okan deposit.

Peter McKellar—Iron is widely distributed over the lake Superior district, and there is a great amount of it; often it is low grade, as low as twenty-eight or thirty-six per cent. At Wabagon there is an immense deposit, but though it looks well the iron only goes about 35 to 40 or 50 per cent. The best grade discovered in this district is at the Atik-okan or Antler river; it averages 64 per cent., and lots have been got that will go 70 per cent. About three hundred samples have been tested, and there is no deposit on the south shore that is better; it is regular magnetic ore. That deposit is about ninety-five miles from Port Arthur and thirty-two miles from the Canadian Pacific railway. It runs from about sixty to 125 feet above the level of the plain, and is about 300 to 400 feet through. The iron is in two runs of thirty and sixty feet each in width. We can follow it four or five miles and see it crop out here and there, though it is not rich in places. Its strike is east and west, while that of the Minnesota range is north-east and south-west. Another body of similar ore has been found at Rainy lake, and is nearly on a line with the Atik-okan. I understand there is titanium in that, but the percentage is good. The Minnesota iron range enters the province of Ontario near Bass-

On Rainy lake.

wood lake, about 125 miles from Port Arthur. It is hematite, and will yield about 65 per cent. right along. In some places there is a great deal of rock in it, and it is low in grade. It is in very large deposits. At Gunflint it is magnetic, is found in flat beds, and there may be great quantities of it. On the American side mines in the same formation are very rich. The magnetic ore assayed over 70 per cent., and there is no higher grade. The ore was tested in Chicago, and also by Professor Chapman. In Chicago they say there is no better ore in the world. There is a little phosphorus, but very little; there is no titanium or sulphur. I am satisfied it is in very large quantities, and there are millions of tons that may be quarried. On the American side operations are being carried on at Tower, and the mines are producing immensely. It is shipped by railway to Duluth, a distance of ninety miles, and thence to Chicago. There are bodies of iron at the Pic river 60 feet thick. It is magnetic ore, but a great many deposits are silicious, and some have phosphorus all through, and that ruins it. There are other bodies near by that have no phosphorus. There are large bodies of ore that go 50 per cent., but they are very far from navigation and could not be worked now; the beds are from thirty to fifty feet thick. At Jackfish bay we found some bodies of magnetic ore, but they did not continue well. There is hematite ore on the Mattawa river, but a great deal of it is too low grade. It has not been well explored. There is lean ore west of the Kaministiquia river, running north-east and south-west, and there is also a great deal of lean ore in the township of Moss. This is in the Huronian formation, similar to that in which the good ore occurs. The walls of the iron ore are sometimes quartzite, sometimes jasper, and sometimes chloritic slate or diorite.

The Minnesota range in Ontario.

Iron deposits on Pic river.

Jackfish bay.

On the Mattawa and Kaministiquia rivers.

In Moss township.

Dr. Henson—I have seen a deposit of magnetic iron ore about 50 miles north of the Canadian Pacific railway, on Eagle river. It seemed to be a large deposit as seen from the river.

Deposits on Eagle river.

LEAD.

Many lead veins are found in the province, but none are now being worked, and it may be said that as yet none have been successfully developed. Evidence is given with reference to the argentiferous galena vein near Garden river, east of Sault Ste. Marie, and also the galena vein in Frontenac near Kingston. The latter is described by Mr. Vennor in the Geological Survey report, 1866-69. The silver carrying veins of the Port Arthur district all carry more or less lead.

Argentiferous galena.

The Ramsay lead mine, near Carleton Place, county of Lanark, was the only location visited by the Commission where galena alone had been worked. Some lead was smelted there, but the enterprise was not a success. A calcspar vein cuts the calciferous dolomitic limestone and is said to run into the Potsdam series below, where it narrows, and into which it has been followed forty feet without improvement. Its strike is north 40° west, and on the surface is from two to four feet wide. The shaft was put down, we were informed, to a depth of ninety feet, and at fifty feet, just above the sandstone, it was two feet in width. Galena crystals occur disseminated in bunches here and there through the vein. Most of the ore was obtained from open cuts and surface excavations along the vein, and we were informed that 29 tons of lead was smelted one summer. The ore was rolled and concentrated, and then smelted in an open hearth with a cast iron pot below to receive the metallic lead. Across a field to the east of the Ramsay shaft is another similar and apparently parallel calcspar vein, carrying galena in the same manner. The vein is four feet wide and appears well defined in close grained limestone walls. The strike is north 15° west.

Ramsay mine.

J. M. Machar—I am a barrister and live in Kingston. The Frontenac lead mine location is on the south half of 16 and the north-east 120 acres of 15 in the 9th concession of Loughborough. The vein crosses both of those lots from south-

east to north-west, cutting across the strata. The country rock is gneiss. The vein was discovered partly by the out-croppings, and partly by the existence of sink holes on the course of the vein. It is composed of calcspar, and varies from 12 to 15 feet in width. It carries galena pretty much all through, some parts being richer than others, and 5 oz. of silver to the ton of galena. Taking the whole vein matter it goes 12 per cent. of galena. Our method was very poor, and we just about paid our outlay. In 1875 we made a lease to F. Stockwell for ten years at $1,000 a year and a royalty of five per cent. The rent was paid for the first five years, and we hold a judgment for the balance of the term. Stockwell organised an English company with a very large capital. This company worked for about a year, and I attribute their ill success to bad management. They put up smelting works and smelted for a couple of years at intervals. The works were put up in 1879, and the last smelting on account of this mine was in 1881 or 1882. We had three American hearths at the mine, and did a considerable amount of smelting. The galena was pretty well distributed all through the vein, which seemed to improve downward and westward. We went down about 100 feet; the company went about 28 fathoms before they stopped at the main mine. The last piece they took out was a cubic foot in size and weighed about 200 pounds. We drifted into the shaft from the bottom of the hill for about 300 feet along the vein, and the English company had a level below that. We did some stoping and the English company did some also. They had another level about 50 feet further down again, but I don't think they did any stoping between the first and second levels. The English company was as badly managed as it could be. To begin with, it was stocked for an absurd amount, and I don't think much was paid in. I have seen the captain speechless with drink, so that between mismanagement, dissipation and general recklessness there could be but one ending—failure. Mr. Stockwell tried to get a renewal of the lease so as to organise another company in England. He got an option from us, but it ran out in July last and we declined to extend the time.

The Frontenac location. Worked by an English company. Smelting works. Extent of mining work. Causes of failure.

Charles Clymo—I am a miner and was born in Cornwall, England. At present I live at Carleton Place. I worked in mines from the time I was 13 years old till I was 27 in England. The old Ramsay mine near Carleton Place was down about 50 feet when I came here. We put in a 12-inch pump to keep down the water, instead of the two pumps they had before, and which were not sufficient. We followed the vein till we came to the sandstone. At 50 feet the vein was about two feet wide, but where we struck the sandstone it got to be very small. We went down into the sandstone about 40 feet; it was of a pink color. The vein could be traced for miles. We did not drift at all; we could not drift, because we struck the sandstone too soon. I cannot tell you how many tons were taken out while I was there, perhaps between 10 and 20 tons. The mine had been worked some years before I arrived; one man had smelted 39 tons. How much was taken before that I cannot tell. The smelting works were put up before I came, and I have been told that 29 tons were smelted one summer. I cannot tell what it went in silver to the ton, but I think it was about 7 or 8 oz. There are other veins to the north-east I believe, but I did not work on them; I did on Mr. Wylie's claim to the west. There is a vein to the west six feet wide, and speckled all over with lead. These veins are good, I think main lodes, as we call them; both walls are the same. I saw barytes in the vein, but the vein stuff is calcspar. There was a good deal of barytes in places, and some of it very good.

The Ramsay mine. Smelting works. Composition of the vein.

W. H. Wylie—I am a woollen manufacturer, residing in Carleton Place, but I have been interested in mining properties. The first in which I was interested was a galena mine in the township of Ramsay, on lot 5 of the 4th concession, I think. It occurs in a vein in crystalline limestone, and the strike is east and west. Towards the east it went into the gneiss rock, and after that it pinched out and we lost it. On the west we lost it in the gully. We did not trace it any farther, as it was the edge of the lot. We traced it altogether about half a mile; it was angling across the lot. The width of the vein was about four feet, ranging from two to five feet. The vein matter was calcspar and some barytes. We spent considerable money in opening it up; we sank one pit 13 feet, and another 12 feet. We had several analyses made, the first showing lead, gold and silver—$75 gold, $22 silver, and 60 per cent. lead per ton. The analysis was made by Dr. Gertwood, of Montreal. The assay was of selected ore. There were some nuggets of lead. We did not find any free gold, and I am doubtful about the occurrence of gold, unless it was in mispickel. We got some mispickel and some copper pyrites in the vein. We took out considerable, but never shipped any away.

Galena veins in Ramsay.

John S. Skewes—I live near Echo lake and am at present caretaker of the Victoria mine. I first took charge of the Victoria mine in the fall of 1877 ; at that time the shaft was 50 feet down and I sank it 410 feet. The vein itself is 49 feet wide ; the shaft is 12 by 6 feet, and the pay streak is from three feet down to a few inches. The general course of the vein is about north and south. All that was shipped was hand-picked and put up in barrels. Some shipments were made before my time, and we made three or four shipments in 1878 and 1880. A very large shipment was made in 1880, but I cannot tell you the number of tons, neither can I tell you the total amount shipped ; Mr. Ross of Quebec has a record of that. We have ready for shipment about 40 tons of first class ore, and we have about 5,000 tons ready to concentrate from which we could possibly get 1,000 tons of dressed ore of 60 per cent. lead, and perhaps 37 ounces of silver to the ton of lead. Besides the 410 foot shaft there is one of 100 feet. There are drifts at 150, 210, 265, and 327 feet from the surface, and there are cross-cuts at 50, 100, 150, 237 and 410 feet. We had a steam hoisting engine of 15 h.p. and a second one that we never put in position. We have on hand the machinery for concentrating, crushing etc. When I took charge there were about 79 men employed, most of them building, chopping and making roads ; 9 of them were miners. The second year there were 27 miners, the third year we were idle and the fourth we had 27 ; the highest we had was 35 I think. The number of surface men was diminished after the first year. In the winter we sometimes had 30 or 40 Indians chopping wood, but they would not work regularly. Our regular surface hands were a blacksmith, a carpenter, teamster and two engine drivers all the year round ; other men were employed improving the road. The ore was shipped to Swansea and was sold for what it would bring in the market. Some shipments were made to Baltimore, Wyandotte and Kingston the first year. After that it all went to Swansea. We got credit for the silver. The Hon. J. S. Ross of Quebec is the president of the company ; the directors are Col. Rhodes and J. J. Scott of New York. The capital stock was $400,000, of which $95,000 is still unsold. There were not many American shareholders ; originaly there were only three persons connected with it, Messrs. Rhodes, Ross and Campbell. Campbell got into financial difficulties and his stock was distributed among his friends. Our mine is at present filled with water. The Cascade mine is close to ours and is supposed to be on the same vein. It is owned by a Chicago company. It was worked to a certain extent for about four years and closed down about two years ago. One shaft was put down to a depth of about 200 feet ; some cross-cuts were made, two levels extended about 200 feet, and some stoping done. The general character of the vein was about the same as ours, the walls being granite. The mine was shut down on account of the extravagance of the manager. They had hoisting machinery, a 25-h.p. engine in the mill, and a Blake crusher. Miners were paid about $2 a day ; surface men from $1.25 to $1.50. Blacksmiths, engine drivers and carpenters would get the same as the miners. The assay from shaft 2 of the Victoria mine shows at 100 feet 13.2 oz. silver and 54 per cent. lead. Shaft 1, at the 100 ft. level, 23 oz. silver and 72 per cent. lead ; at the 150 ft. level, 26 oz. silver and 76 per cent. lead ; at the 265 ft. level, 10 oz. silver and 62 per cent. lead, and at the 327 ft. level, 29 oz. of silver and 54 per cent. lead.

The Victoria mine at Echo lake.

Extent of the working.

Miners and surface men.

Stockholders in the company.

The Cascade mine.

Assays of the Victoria mine ore.

E. B. Borron—Lead is not as frequently met with on lake Superior or lake Huron as copper. The most promising vein I have seen on either lake was that at Black bay, already alluded to as the one in which Prof. Chapman found the first gold. This was afterwards called the Enterprise mine, and work was commenced upon it shortly before I resigned my position as mining inspector. From Mr. Blue's descriptive catalogue of the mineral exhibit of the province at Cincinnati, page 29, I see that a shaft has been sunk to a depth of over 200 feet, and some 200 tons of ore taken out, but that it did not pay on account of the ore having to be sent to Swansea to be smelted, and that in consequence operations suspended about twelve years ago. Two mines on Garden river, near Sault Ste. Marie, have been worked off and on for several years, and one of them, the Victoria, has produced some good galena, but with what results I cannot say. I have seen lead ore at the river Temagami, also on the route between lake Temagami and the main Montreal river, and at various other places in the province, but nowhere in such quantity as would lead me to believe that the veins could be worked otherwise than at a loss, even under more favorable circumstances as to position, unless the galena was very rich in silver.

The Enterprise mine at Black bay.

Garden river mines.

In the Temagami region.

Smith & Lacey mine.

The Smith & Lacey mica mine is situated in the township of Loughborough, county of Frontenac, a few miles from the village of Sydenham. A zone of enormous mica and pyroxene crystals runs in a north-westerly and south-easterly direction through the property, and in this zone there are also phosphate masses and calcspar in places. There are no signs of vein walls, nor can it be noticed that the crystallisation is confined within the boundaries of a certain bed in the formation. It seems rather, as in the case of other mica-bearing rocks in this district, that in certain places and along certain lines a larger development of the component parts of the rocks has taken place. The same minerals are visible elsewhere in the formation, constituting the rock composition, but much smaller in size. A shaft has been sunk on the mica deposit which 20 feet below the surface has been opened out to a large chamber, 130 feet deep by 150 feet long, and about 15 feet wide; this distance across the formation may be said to represent the width of the zone of largest sized crystals. (Fig. 24.) The mica crystals are in places six feet long, the largest being seven feet square. They are for the most part more or less twisted, and there is an enormous waste in manufacture, but owing to the great quantity of the crystals the production is large, and could be increased to almost any extent. The mica is dark or amber colored, but does well for stoves and all the other purposes for which mica is used in which a white color is not essential. Fig. 25 represents the section exposed at the north-west end of the excavation. The mica crystals are at all angles, but seem as a rule to be more often inclined to the vertical than to the horizontal.

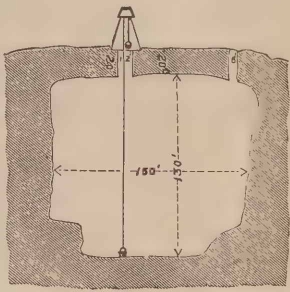


FIG. 24. The Smith & Lacey mine.

FIG. 25. Section of the Smith & Lacey mine.

g. Phosphate and pyroxene, 4 feet. l. Micaceous pyroxene rock. m. Mica rock, 3 feet. n. Pyroxene, 2 feet. o. Large mica crystals with pyroxene crystals.

Perth mica mine.

The Perth mica mine is located on lots 15, 16 and 17 in the 9th concession of North Burgess. It occurs in a green steatitic rock which, for about 50 yards in width, is mica-carrying. The total width of the band is 150 to 200 yards, occurring between a quartzose gneiss on the south and a felsitic gneiss on the north side, the dip being to the south. On this mica-carrying portion a number of pits have been sunk for 200 yards along the formation, from which more or less mica has been taken from time to time. As a rule the mica-bearing parts keep an east and west course—in places as a species of veins—which seem to be generally parallel. The work at present carried on is in a shaft or deep excavation, which opens out below in each direction to dimensions of 60 feet in length to 12 or 15 feet in width. The depth of the lowest working is about 80 feet. (Fig. 26.) The mica is disseminated in minute crystals through

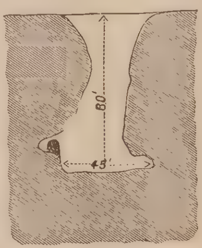


FIG. 26. Perth mica mine.

the green steatitic rock, and here and there it occurs in bunches of crystals, some of which are twisted and others regular, varying in all sizes and at all angles, but chiefly with cleavage planes more or less perpendicular. One exposed crystal was two feet long by one foot broad, and another one foot by one foot four inches. It is a soda mica and of a good clear color, with slightly yellowish tint, and tough enough for all practical purposes.

A mica property has been discovered on lot 29, 12th concession of Hungerford, county of Hastings. The formation strikes north-east and south-west, and dips to the south nearly perpendicular. A strong band of highly micaceous rock strikes through the district, on which five openings have been made in this property at places where the mica crystals have been developed most strongly. Where opened it appears that quartz and felspar crystals are developed with the mica, and also crystals of tourmaline. Black specks occur in places in this mica, and are supposed to be due to the presence of very small tourmaline crystals; but these specks occur only on some layers in the crystals. The mica is associated with masses of quartz and felspar, and sometimes in massive accumulations almost vein-like in their closely aggregated association. The quality is good where not spotted.

Hungerford deposit.

D. E. K. Stewart—Two years ago I purchased a mica mine on lot 29 in the 12th concession of Hungerford, and have been doing some development work upon it since. There are five pits upon it, varying in depth from 10 to 18 feet. All the pits show cubes of fine white mica, some of them cutting as large as 6 by 8 inches, and it is pronounced to be equal to any that has been offered on the market. I think the vein is about 12 to 14 feet wide. The mica occurs in quartz and felspar, the country rock being granite. A great deal of the mica is free from flaws, and improves noticeably at a little depth from the surface. It is about 17 miles from Madoc. I have not yet worked the mine as a commercial enterprise.

A vein in Hungerford.

Jonathan P. Lacey—I am of the firm of Isaiah Smith & Co., of Sydenham, miners and dealers in mica, phosphate, etc. We own and work a mica mine on the west half of lot 11 in the 7th concession of Lougborough. It was discovered by phosphate prospectors eight years ago, and a small opening was made on it in the hope of its leading to a phosphate deposit. We began mining for phosphate in this district seven years ago, but during the past four years our attention has been given almost wholly to mica mining. Our first work was done on the mine in 1884, when we began to put down a shaft. The vein is well defined within walls of pyroxene rock, and varies in width from ten to twenty feet. Its strike is north-east and south-west, and is nearly perpendicular. The crystals lie very irregularly, from horizontal to vertical, and the vein is free from rock matter to a depth of a hundred feet. We have now reached a depth of 130 feet, at which point considerable quantities of phosphate and small portions of mica rock, fluor spar and crystalline limestone occur with it. The crystals vary in size from a foot to six feet, and some have been found weighing over ten tons. We have stoped out along the vein a distance of about 130 feet, from a depth of 20 feet in the shaft to its bottom. The mine is well timbered throughout and stulled or roofed at intervals of twenty feet, to prevent rock matter falling upon the miners. Twelve men are employed at the mine, but no machinery is used excepting a horse-power hoist. The average rate of wages is a dollar per day and board the year round, and we work without interruption summer and winter. At the finishing works we employ eight men, at $1.25 per day without board. The mica is cut into various sizes and shapes for stoves and other purposes, and we find a market for it in Canada, the United States, England, France and Germany. It is of a rich clear amber color, and the cleavage is perfect. Very rich shows of phosphate occur in the mine, and this year we will take out about one hundred tons. We are now opening a white mica property in the northern part of the county of Addington, on a vein which promises to give excellent results. In the same locality we have discovered a vein of quartz 30 feet wide, bearing free gold, but no development work has been done upon it.

Discovery of the Loughborough mine.

Occurrence of the mica.

Workings of the property.

Workers and wages.

Markets.

Phosphate.

White mica in northern Addington.

Mica in Miller and Bedford.

Joseph Bawden—There is fine mica in the south-east part of Miller. It is owned by some parties in Ottawa, and is on the property of a man called Landry. There is mica also on the Bedford iron company's property.

Mica in Miller township.

George McMartin—I was sent to open a mica mine in the township of Miller. It is muscovite of very good quality, and the crystals are very large. The vein is in grey granite, and the vein matter is quartz and felspar. The mica is as fine as that of Villeneuve. The mica is figured near the surface, looking as if trees had been painted on it with the leaves all gone. In some places it is free from the figuring and the mica is beautiful. At Sydenham there is amber mica, and there is another deposit of mica on the other side of the Rideau, in Crosby, I think. It is the same quality as that of the Burgess mine, but not as large a body. The Burgess deposit is on lots 15, 16 and 17 in the 9th of North Burgess. The mica occurs generally in pyroxene and soapstone, and is cased in granite. At the Burgess mine the mica-bearing part is 50 yards wide, and the length about 600 feet. In one or two places some ochre occurs, and the mica is near the ochre. Taken as a whole it is very clear for that quality of mica. In the main lead it runs every way. I think it is a main vein with faults in it, and that bunches of mica occur all through it. I do not think it is a continuous vein by any means. The demand for mica has been very good for the last few years. Of course we cannot compete with the Villeneuve for quality, but our price is lower and we can sell any quantity at a lower price. We reckon on getting 200 lb. of good marketable mica to the ton, as it comes out of the ground. That costs about $100 a ton in the rough, and about $100 a ton to cut it afterwards. The selling price is from 40 cents to $5.75 per pound, according to size. We cut nothing less than 2 by 3 inches. The principal demand is for 5 by 7 inches, which sells for $5.75 a pound. The market for mica is in Canada and the United States. It is used for stoves and for electric motors. In a pound of mica 4 by 6 inches there are 120 sheets, which retail at ten cents each. I do not think the black is as good as the white mica for lubricating purposes. The best for that purpose is the white soda mica, such as that of the Burgess mine. As a general thing where we find dark mica and pyroxene in this district we find phosphate near by, with granite generally as the casing. Sometimes we find diorite, but not very often.

The Burgess mine.

Markets and uses of mica.

Phosphate.

Mica in the Perth district.

W. A. Allan—I have developed two mica properties, one in the township of Villeneuve in Quebec, and one on lots 16 and 17 in the 9th of North Burgess, in the county Lanark. The crystals are irregular through the vein; some of them stand on edge, and others at different angles. The vein matter in the Perth district is a grey pyroxene, and there is a great deal of the rock commonly called soapstone, but which really is not soapstone. The largest crystals taken out would be about 15 by 20 inches; they cut into plates of about 10 by 12 inches. They are very regular and not at all twisted out of shape. The mica is not as good as what is got out of the Villeneuve, but there is a larger marketable quantity of it. The market is limited. The price for mica 1½ by 4 inches is 15 cents a pound; 6 by 6 is worth $6 a pound. There is no difficulty in selling the large sizes in New York city. The market for mica is in the States and here; there is no market for it in Europe that I know of. I sent some to Hamburg and London, and it was returned in both cases; they wanted to know what its uses were. In Germany they use a very little of it for toys. It is admitted free into the States. I have seen two or three deposits in Ontario, but the quality was not very good; it was not clear. There is very little white mica in Canada. In Villeneuve the mica occurs in a mountain of quartz and felspar, very irregularly; there is considerable tourmaline through it. The largest crystal found there, was, I think, 24 inches square, but that is very rare. If the mica would average 3 by 5 inches it would be doing very well, and that would be worth $4.75 a pound. The Burgess mine was worked before it came into my possession some four years ago. I have sunk a shaft about 60 or 70 feet, and the whole floor is a mass of crystals. That shaft is 10 feet by 12; there are three veins coming into it, and I think they will all join together lower down. The crystals vary very much in size, some being as much as two feet in length, some are much less. They are very irregular in shape, being sometimes triangular, sometimes hexagonal, and sometimes partly round. They range from an inch in diameter to 18 inches. Sometimes we get a large crystal 20 inches across the face, and a fracture may spoil it. We find no difficulty in getting all the skilled men we require as mica cutters. There is no trouble, as we cut by blocks of different size. I am working the mine with five or six men; all the mica is cut for stoves. I had 20 tons ground and sold it in Montreal, where it was used

Markets for mica.

The Burgess mine.

Uses of mica.

in the manufacture of lubricators. It is very good for that purpose. It was only the refuse that was ground ; I sold it for $45 a ton. The Cyclone company ground it for $20 a ton for the first lot, and $40 a ton for the second ; they only did it fairly well.

E. V. Wright—There is good mica on the Petewawa river. Specimens were brought in by an Indian, but I cannot say where they came from. The Indian said he could get it of almost any size. The piece I saw was about three or four inches, and I think it appeared as if broken off. It was very transparent, and perfectly white like a piece of glass. I think it came from about forty miles up the river. I found some very heavy micaceous iron that one can rub to pieces like dust ; it is very heavy, and is on the Ontario side on a small lake near lake Temagami.

White mica on Petewawa river.

Micaceous iron.

NATURAL GAS.

The enormous and apparently permanent yield of natural gas in the United States to the south of Ontario makes the subject of natural gas well worthy of consideration from an economic point of view. This is the case especially as a large flow of gas has recently been struck at Kingsville, in Essex county, besides discoveries at Courtright on the St. Clair river, at Collingwood on the Georgian bay, and at Port Colborne on lake Erie.

Found at several points in Ontario.

In the report of Joseph D. Weeks, in the volume of Mineral Resources of the United States for 1887, it is stated that while natural gas has been found from the Drift to Potsdam sandstone it has been chiefly in the Trenton limestones of Ohio and the palæozoic strata of the upper Coal Measures of Pennsylvania that the great deposits have been struck. The highest stratum in which any considerable quantity has been found in Pennsylvania is the Homewood sandstone, the highest of the three recognised members of the Pottsville conglomerate, the lowest being the Kane sand in Elk county. Mr. Weeks estimates that the amount of coal displaced in Pennsylvania in 1887 was 9,867,000 tons, valued at $15,835,500. The total thickness of the strata which have produced gas in different parts of Albany and Greene counties in the state of New York is computed by Mr. Ashburner to be at least 12,000 feet, extending from the Catskill white sandstone to the Trenton limestone.

Its occurrence in Pennsylvania.

Gas producing strata in New York.

In Ohio and Indiana, according to Prof. Orton, the only important source of gas is the Trenton limestone. Unlike the Pennsylvania fields, he says, these western rivals are not confined to anticlinals or arches, but stretch out like coal fields. The Trenton limestone in those states, however, is largely productive only when its upper portions have been replaced by dolomite or magnesian limestone, and it is only in the fortunate exceptions that porosity and structure combine to make it a source of gas or oil. In Indiana Dr. Phinney has shown that gas has been found in commercial quantities chiefly in the Cincinnati arch or anticlinal, which extends from the south line of Tennessee through Nashville and Cincinnati to lake Erie, between Toledo and Sandusky. This arch, as pointed out on page 42, extends under the lake and crosses Ontario in the counties of Essex, Kent and Lambton. "That the gas is found in this arch," Dr. Phinney observes, "is no accident, but the result of well defined and fixed laws, that govern not only the distribution of gas, but oil and salt water as well." Gas and oil will, no doubt, be found in many places outside of the productive area proper, but the flow will be small. This appears to be true in Ontario as well as in Ohio, for although small shows of

Its occurrence in Ohio and Indiana.

The Cincinnati arch traced into Ontario.

gas have been struck in various localities in the province, it does not appear to exist in abundance anywhere excepting possibly in the county of Essex.

Natural gas in Pennsylvania.

Archibald W. Dingman—I live in Toronto, and am a soap manufacturer. I have been engaged in oil and gas operations in Pennsylvania, my experience running over a period of about three years—from 1879 to 1883. I have explored both for oil and gas in McKean county, Pennsylvania, and in the Kane district in that state, near some of the tributaries of the Ohio. The wells or "gushers" of that region are counted among the best. We were boring for oil when we first struck gas. The gas was found at 2,250 feet, in the same sand rock as that in which we expected to find oil. My observation would not lead me to believe that a similar formation exists in Ontario. I have examined the oil regions in the counties of Lambton and Essex in this province, and so far as the Petrolia oil region is concerned I would not expect gas to be found until they strike the Trenton formation; they are now in the Corniferous. This is borne out by the fact that gas has been found in Indiana and Ohio in the Trenton formation. The wells at Kokoma and Terre Haute, Ind., and at Findlay, Ohio, are from 870 to 912 feet in depth. A log of a gas well at Kokoma shows: Drift, 5 feet; Niagara limestone, 400 feet; Hudson River and Utica shale, 498 feet; then four feet of an interval to Trenton limestone, and five feet into the limestone. I have not visited the gas wells in the county of Essex. I know that there was a well drilled some 1,200 feet at Comber in that county, but I am unable to say to what depth the well at Kingsville was bored. It was reported that gas was got at Collingwood, but in what quantity I am not aware. I have a record of a well put down at Whitby a short time ago for gas. The total depth of the well is 728 feet, of which 70 feet is through shale and 600 feet through Trenton limestone. Two shows of gas were found, one at 450 and the other at 710 feet, but they were soon exhausted. A well was put down in Toronto about ten or twelve years ago at the Copeland brewery. They were boring for water and went down 1,2[illegible]0 feet. The log shows 40 feet surface, 550 feet shale, 10 feet of an interval, 600 feet limestone, and then the granite. Some salt water and some gas were struck. I have also a record of a well at the asylum in London, put down by the Government. It was drilled to a depth of 2,255 feet. The log runs: 120 feet of gravel and clay, 300 feet of shale, 1,000 feet of limestone rock, 150 feet of grey shale and salt, and the remainder red shale. They got water at 140 feet from the top, and 25 or 30 feet of good salt at a depth of about 1,600 feet, but there is no record of gas. At Dundas a boring was made for 1,600 feet without striking the Trenton limestone. There was red shale, as at London, but no lime rock. A well was also drilled at Port Colborne, but I cannot give its depth. About twelve years ago a well was drilled in the township of Hillier, in the county of Prince Edward. The depth was 760 feet to the granite, and then 25 feet into the granite. An abundance of water was found, but the driller does not recollect whether any gas was struck. The granite comes up within ten miles of that place. I do not know of any district outside of Essex where gas has been found in the Trenton limestone in paying quantities. Between Ontario and Quebec the formation of the limestone is so similar to that of Indiana and Ohio that there is a strong probability of gas and oil existing there. Many anticlinal ridges are observed in that section, and where these are found under like circumstances there is almost sure to be oil or gas. However, I have no knowledge of either of these being struck up to the present time. I am at present engaged in organising a company to make a series of tests for oil and gas at certain points east of Toronto. With regard to the origin of natural gas I may say that there are two opinions held—one that it is a chemical formation in a geological sense, and the other that it is the result of decaying animal matter in the rock. Of course there is a chemical action in the latter case too, but not from original elements. Natural gas is a product of petroleum, but we often get it without finding the petroleum. It is in the petroleum just as we may find benzine, tar, paraffine, etc. It may be that we get gas from the original crude, but that would be hard to prove. Geologists find that the best results are given when the Trenton limestone is not more than 200 feet below the tide level. Below that there are no anticlinal arches. The theory is that the salt water drives the gas up by pressure. Where the rock extends over 200 feet below tide water there is very little possibility of getting gas of commercial value. That is a theory which has been demonstrated to be a fact as far as the Indiana and Ohio regions have been explored, as the actual records of the drill prove it. There are always better results above sea level than below, but the best point is where the pressure is

Found in the Trenton formation.

Borings in Ontario.

Theories of the origin of natural gas.

equalised. The rise or fall of the tide, however, does not seem to affect the flow, which is usually steady.

James Carter—We put down eight wells for natural gas at Courtright, but only got gas to any extent in three of them. We found it in a ridge or vein of sand, but the width of it I do not know. The vein is supposed to run north-east and south-west. The average depth of the wells is about 105 feet. With the exception of the vegetable soil it is blue clay all the way down. I do not know that it has ever been tried for manufacturing purposes. One of our wells continued to blow for two days and nights, and several carloads of fine sand mixed with water were thrown out. The sand is dark grey in color. After it settled down the gas continued to flow till it got choked up. We cased it down about 110 feet to the sand, but could not keep it open. I cannot really say whether the gas gave out or whether the pipe got choked up. No wells have been put down successfully in this sand formation. The existence of gas has been known here for twenty-five or thirty years, but it has never been used to any extent. About a quarter of a mile from one of our wells it has been used for about a year in a private house for fuel. It burns with a yellow flame, but by adding air to it in the pipe it becomes white. Natural gas at Courtright, but in doubtful quantities.

Wm. Murdoch—We have natural gas in the Port Arthur district. No borings have been made, but it comes up in different places. On Silver islet the gas was met with when they were between 600 and 700 feet down in the mine. Found in Silver Islet mine.

PETROLEUM.

There are two areas in the county of Lambton which yield petroleum in paying quantities, one at Petrolia and the other at Oil Springs. Taking the corporation of the town of Petrolia as a centre, or, more exactly, the Imperial refinery, the upper field extends to the north-west by west for nine miles, and to the south-east by east for four miles, with an average width of two and one-half miles. The Oil Springs field is six or seven miles to the south of Petrolia, and runs in the same direction as the Petrolia field for a length of two and one-half miles and a width of one mile, the southern boundary of Oil Springs being about the centre of the territory. Two petroleum producing areas.

THE PETROLIA DISTRICT.

The oil is struck at Petrolia at from 465 to 473 feet in depth, and is stated to exist in a porous dolomitic limestone from one or two to five or six feet thick, brown in color (probably from the petroleum), and very soft. A log given by an experienced driller shows: Petrolia field.

Alluvial matter	100 feet.
Limestone rock	35 to 40 feet.
Soap rock and blue clay below	130 feet.
Middle limestone	15 to 18 feet.
Lower soap rock, shale	40 feet.
Hard limestone rock	90 feet.
Limy freestone	55 feet.
Total to oil rock	465 to 473 feet.

The well bored on lot 12, concession 11 of Enniskillen, gave:

Surface clay	104 feet.
Limestone	40 feet.
Shale	130 feet.
Middle lime	15 feet.
Lower shale	43 feet.
Hard white limestone	68 feet.
Soft white limestone	40 feet.
Big lime or oil-bearing rock	25 feet.
Total to oil rock	465 feet.

There are about 2,500 wells in this field, according to the evidence.

PRODUCING AND STORING PETROLEUM.

Drilling the oil wells.

The wells are drilled $4\frac{5}{8}$ inches in diameter, and where casing is put down it is rimmed out three-quarters or one-half of an inch, the casing being $4\frac{5}{8}$ inside and $5\frac{1}{8}$ inches outside diameter. The hole is put down in about five or six days, and costs from $150 to $160. In the early days the cost ranged from $1 to $3 per foot, and the time occupied from two to six months. Wooden rods are now used altogether instead of cables, a steel drill $3\frac{1}{2}$ inches in diameter and 25 to 30 feet long being attached to the lowest section. Two shifts of three men each form a drilling gang. These Petrolia drillers are very expert, and are called for all over the world, much work being done by them in Europe, Asia and Australia.

Working the pumps.

When the drilling is completed a pump of $1\frac{1}{4}$ to $1\frac{1}{2}$ inch tubing is put down, and the well is ready for operation. By a combination of pump rods working from a horizontal wheel, and so arranged that their weights about balance one another, one engine can pump a large number of wells—as many as 90 in some cases. These driving rods are known as "jerkers," and are driven by an engine of about 12-horse-power. The wells yield at the present time about half a barrel of oil on the average per diem, and all have to be pumped. In the old days some flowing wells were struck, and as in some cases the tools used in drilling these wells suddenly dropped where oil was struck, it was inferred that large crevices existed which held accumulations of gas and oil. Old wells are being constantly abandoned and new ones drilled.

Storage tanks for petroleum.

The petroleum after being pumped into the wells is run into large underground tanks, which are built by boarding up an excavation and covering it over. The soil about Petrolia is an impervious clay, and these underground tanks hold the oil perfectly. They are always kept filled with either oil or water, as otherwise they would cave in. An ordinary sized tank is 60 feet deep by 30 feet diameter, holding 8,000 barrels. From these tanks the oil is pumped to the refineries.

Composition of the petroleum.

The Petrolia oil is an impure variety of petroleum, much tainted with sulphur. The odor of sulphuretted hydrogen is very strong all about the neighborhood. In the evidence the oil is alluded to as consisting largely of an abnormal series of hydrocarbons. The crude contains less of the illuminating oils than the Pennsylvania crude, and more of the heavy lubricating oils and paraffine. Much ingenuity has been resorted to in order to remove the sulphur and the free carbon of the broken molecules of hydrocarbons, which together have the effect of causing a bad smell, encrusting the wick and smoking the chimney when burning.

DISTILLING AND REFINING THE PETROLEUM.

Process of distillation.

The crude oil is distilled in large sheet-iron retorts. The heat is furnished by a spray of mixed petroleum and steam, injected into the fire chamber below the retort, which is lined with fire brick. The distillate is carried through tubes immersed in long vats of water. As the different distillates make their appearance, at various stages of the process, they are led into different troughs and flow into separate tanks. First the incondensable gases, gasoline and naphtha, come off; then the illuminating oil; following that the

intermediate and wool oils, and lastly the lubricating oils; while an incrustation of carbonaceous matter or coke is left in the retort. This coke is sold in the locality at $1.50 per ton, and makes a good fuel. All the grades of the distillation are divided at will, either by stopping the process at various stages or by subsequent redistillation and treatment into an almost endless variety of lighter and highly combustible intermediate illuminating and lubricating oils, and also into such solids as vaseline, paraffine, etc. Tars and asphalts might be produced from an oxidised matter which is thrown away. The products of evaporation may be roughly divided into 40 per cent. illuminating oils, and the other 60 per cent. the above mentioned articles; or, more exactly, burning oil 38 to 39 per cent., gas oil 17 per cent., tar 18 per cent., waste 10 per cent., water 6 per cent., and coke 9 per cent. In the illuminating class the specific gravity of the following three brands will serve as an example of the gradation according to quality: Water White .786, Economy .800, Standard .802. The fire test of 95°, at which the oil ignites, is common to all grades of illuminating oil. Another grade of brands, with all higher products mentioned after incondensable gases have gone off, is:

1st product		74 naphtha.
2nd "		62 benzine.
3rd "	water white illuminating oil	.788 gr.
4th "	carbon safety illuminating oil	.796 gr.
5th "	standard illuminating oil	.802 gr.
6th "	intermediate oils (for gas works)	
7th "	neutral (for wool)	.850 gr.

The refining process.

The process of refining the illuminating oil is to agitate it with 2 per cent. of sulphuric acid, (which costs $1.40 per 100 lb. at Petrolia,) to remove the free carbon or tarry materials which are drawn off below, then, after washing it with water, caustic soda and litharge are added. The litharge (oxide of lead) combines with the sulphur and forms lead sulphide. Flowers of sulphur is then added, which precipitates the lead and other impurities, and the oil is left cleared, but enough sulphur generally remains to be a source of trouble.

A patent process of refining.

A process which has been patented is in use in several of the refineries. It consists in re-distilling the oil after the litharge and caustic soda have been added, and before the flowers of sulphur has been put in. Most of the sulphur is then left in the retort in combination with the lead. The rest of the process is then carried on with the re-distilled product as above described. Finally, in all processes, the product is bleached in the light in an open vat. The resulting illuminating oil is shipped in very strong barrels, but some Water White is put up in square tins.

Other products of petroleum.

The tar, or residue after the illuminating oils have come off, is re-distilled, from which about 70 per cent. of gas oil used in making illuminating gas and 30 per cent. paraffine oil are obtained, according to the grade required. The paraffine oil is put into a freezing vat, and from 8 to 10 per cent. (or one pound to the gallon) of paraffine wax crystallises out from it. This wax has all the oil squeezed out by pressure, and is refined by chemicals, one part of the resulting yield being made into wax candles and the other smaller portion into a wax which is used as chewing gum and for various other purposes.

The residue oils, after the paraffine has been crystallised, are made into lubricating oils, such as paraffine oils, cylinder, mineral lard, mineral seal, neutral, black lubricating, axle grease, vaseline, etc.

THE OIL SPRINGS DISTRICT.

Oil Springs field.

At Oil Springs the oil is struck at 370 feet deep, or at about 100 feet less than at Petrolia. From July 1st, 1887, to July 1st, 1888, 244 wells were put down in this district, and at the latter date the number in operation was 964. This field extends over lots 16, 17, 18 and 19 in the 1st and 2nd concessions of Enniskillen, there being 258 wells on the 1st concession and 706 in the 2nd.

COUNTY OF ESSEX.

Oil wells at Comber, in Essex.

Several wells have been put down at Comber. In one the show of oil was found in deep sand at 1,213 feet, and the second in deep sand at 1,240 feet. It pumped 100 barrels of oil, and flows a half barrel per diem. Niagara limestone is found at 600 feet.

MANITOULIN ISLAND.

Manitoulin island.

The Commission also visited some quartzite ridges on Manitoulin island striking north 80° east and dipping 65° north, which are met with on the road from Little Current to Sheguindah. They rise through some bituminous Utica shales, and at the north end of Pine lake petroleum exudes from a hole which, it is said, has been drilled down to the quartzite. In that case it was, of course, useless to drill any further. It is stated that about a barrel of petroleum flows out of this hole with water per diem. The quartzite is very white, and is said to be adapted for the manufacture of fire brick or glass after being ground. There is an unlimited quantity of it.

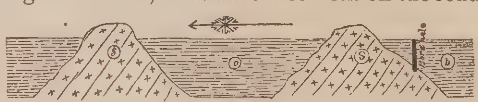


FIG. 27. Section of formation at Pine lake.
b. Shales. s. Quartzite.

Martin Woodward—I am a member of the firm of M. J. Woodward & Co. of Petrolia. I have been in the oil business since 1870, but was interested in some wells before that. I first began business here in 1868, a few years after the first discovery. The process of putting down wells at that time was about the same as to-day, but there are of course some little improvements in the tools and machinery. Before I came here they used to crib down to the rock; that was mostly done in the flats, where they usually struck the rock at 40 feet. There were quite a number of these cribbed wells, and on the high land they generally struck the rock at 96 or 100 feet. I cannot say from recollection how long it took to get down in 1868. The tools were lighter then, and they drilled in wet holes; now they drill with heavier tools and in dry holes, allowing in only the amount of water they require. I have known them to take six months to get a hole down. When I first came here the price was about $1 a foot for ordinary rock, the owner of the well furnishing the casing. Now they use a 4½ inch bit and usually drill a hole in about four or five days, at a cost of about $160 a well, the owner furnishing the casing. The driller puts the pump down and tests it for a day. There are men who make a business of putting down wells, and they run night and day. A gang consists of six men, three working in the day and three at night. Pole tools are now used; they consist of a bit and an iron bar about three and a half inches in diameter, and connected with the beam above by poles. When water is struck now it is shut off with the casing, which is usually at a depth of 270 feet. At 275 feet we get the middle limestone. After putting in the casing they drill in a dry hole, where they can strike a heavier blow than is possible if the well was filled with water. They run with perhaps 30 or 40 feet of water, whatever is required. After the first 275 feet the casing shuts off the water, and in practice that is all the casing put down. The pump is put inside the casing; it is generally from 1¼ to 1½ inch in diameter, and is the ordinary lift pump.

Sinking the oil wells.

The old and new processes compared.

Casing the well.

The average daily supply from a well is from five to ten barrels of water and oil mixed, but of oil they average something less than a barrel a day. I have known as many as ninety wells to be pumped by the one engine. In most cases they use a bricked-in boiler. The drive wheel is connected with a wheel which has a pitman on each side that works a horizontal wheel backwards and forwards. The jerker rods are attached on opposite sides of the wheel and connect with the pump over the hole. Iron rods are used in the pump, their weight being sufficient to make it drop. As far as I know the jerker was first used here; I never heard of it anywhere else before. It was used here before it was introduced in the States. I cannot tell you the number of wells that are being worked in this territory, but I think there are about 2,500. The length of the territory is about seven or eight miles, nearly east and west. It extends into Sarnia township, and seems to be from half a mile to two miles wide. The oil is struck in a kind of lime rock; sometimes in drilling we get a sample of the rock; it is a limestone of the Corniferous formation. At the Imperial works here they went down 1,200 feet, but I cannot tell you what rocks were passed through. They did not get oil at that depth, but they struck salt. I understood at the time that the salt was 175 feet thick. When wells are put down now they don't seem to have the same pressure as in the early days. Formerly in some cases there were large flows; now the oil hardly flows at all, and when new wells are put down it is usual to shoot them with a charge of nitro-glycerine; that is done for the purpose of opening up the rock. The total output of the territory, including Oil Springs, is about 600,000 barrels of crude yearly. When the petroleum is pumped up it is stored in underground tanks where it is kept till wanted. In some periods of the year the demand is greater than in others and more is refined then than the wells produce; then the supply in the tanks makes up what is required. In speaking of a barrel of crude oil we always mean 35 imperial gallons. There are three tanking companies here, but I cannot tell when they were organised. When I came here the principal refining works were at London, and there are I believe two refineries there still, besides one at Hamilton, one at Montreal and one at Sarnia, but the two last named are not working now. In 1870 there were over forty refineries in the combination, and they were mostly at London and Ingersoll, the majority being at London. The business gradually began to centre at Petrolia after the Michigan Central railway came here. There are nine refineries here now. I do not know their total capacity, but I think that including the two refineries at London it is about double what is required. When I came here first they treated the oil with sulphuric acid and caustic soda, and made a very strong smelling oil. The lead treatment came in shortly afterwards. In 1870 we calculated on about 60 per cent. of illuminating oil, but there was a lower fire test then than now. The oil was put in stills somewhat smaller than those at present used, and after it had been distilled the illuminating portion was treated with 2 per cent of sulphuric acid. The tar was drawn off, the oil was washed with water and allowed to stand some time. It was then drawn off and agitated with a solution of caustic soda; then it was put in the bleacher, exposed to the sun, and then barrelled. At that time a great deal of the tar ran down the creek and was lost. Some of the refiners stored it, thinking it would become valuable; and subsequently a good many thousand barrels were sent to Boston and New York. It went in as coal tar, and there was 20 per cent. duty upon it. There was then a duty of 20 cents the wine gallon on crude oil, and 40 cents the wine gallon on the refined. The duty now is 20 per cent. on the refined and the crude oil is allowed free into the United States. At first we were allowed to manufacture of any gravity, but some years ago the law in that respect was changed and the gravity clause was put in; that caused a change in the system of manufacture. The process at the present day is very similar to what it was formerly, except that instead of caustic soda, we mix in oxide of lead dissolved with the acid and agitate with that. It is afterwards treated with sulphur to remove the lead. The lead treatment was introduced I think about 1870. In the last two or three years further improvement has been affected, but it consists principally in increased skill in handling the chemicals. Distillers and treaters understand their work better than formerly. People would not burn such oil now as they used in 1870. It had a very bad smell then; now there is far less smoke and odor than under the old treatment. Our percentage of illuminating oil now is hardly 40 per cent., while under the old system it was 60 per cent. Our percentage was reduced when the gravity test was made. Apart from that we would have to make better oil now. There is a good deal of the tar used for fuel, and above that there is a certain amount of waste, coke and dirt. We get a good many by-products from the tar, paraffine wax being one. But all the refineries are not run the same way; some utilise all

Pumping the wells.

Extent of the oil territory.

The oil bearing formation.

Output of the territory.

Storage of crude

Refineries.

The old process of distillation.

The new process.

Paraffine.

Tar. the products and some do not. Tar has been used for fuel the same as it is to-day during the whole of my time here, and it is the cheapest fuel we have. It is sprayed into the furnace with steam. It could be generally used for fuel, but cannot bear the high freight. There is more benzine made than formerly, about 7 per cent. altogether. After using what we require for fuel purposes we get about 8 per cent. paraffine.

Naphtha. First we make 70 naphtha, then 63 naphtha. The 70 is used for naphtha stoves and such purposes; the 63 is used by painters principally.

Illuminating oils. We manufacture three grades of illuminating oil—Homelight, Economy and Standard. The fire test, which I think is higher than necessary, is about 95. The higher the test the less can be extracted from the crude. Our different grades are of different gravities, Home Light is .786, Economy .800 or .801 and Standard .802 to .803. Our oil is better in some qualities than the American. Our best is equal in color, and has better capillary qualities than the best American. It gives very much the same flame, and of the same color, but is not so free from sulphur compounds as the best American. There has been a prejudice against Canadian oil, and it has had a bad name. Now we are overcoming that, and getting a better price than formerly for our best; we get from 15½ to 17½ cents according to quantity. The best American Water White is laid down in Toronto for 22 cents, and the ordinary grade about 20½ cents. That includes the duty, which is 7.2 cents; there is also a duty on the package. With American oil it is not a competition of price, but of quality. I know instances where our oil is sold for American.

Machinery oils. From the residuum after taking the illuminating oil, we make about all the different kinds of machinery oils that are required. Mineral oils are fast taking the place of animal oils, and very little of the latter is now used.

Wool oil. We also manufacture a wool oil, so that there is very little waste from the crude.

Gas oil. Gas oil is another product. It is used in making gas, and was I think first introduced in Toronto for this purpose. They began using the crude oil, but changed into this intermediate oil. It cheapens the manufacture of the gas very much.

Market for products. Our illuminating oils are all sold in Canada; we don't ship any to foreign countries. We cannot compete with the Americans. They have better facilities for reaching the seaboard, and they have an advantage in the quality of their crude oil. We export some lubricating oils to the States, and supply several railways there. The crude or refined paraffine can be sold in Glasgow or Liverpool. John McDonald and the Imperial Oil Co. refine their paraffine.

Workers and wages. Our refinery employs seventeen men, about 6 or 7 being skilled men, distillers and treaters. The general wages are from $8 to $15 a week. Treaters get from $2 to $2.50 a day, distillers $10 a week and yardmen $8. We use about 75,000 barrels of crude a year.

Wells at Comber, county of Essex. At Comber in the county of Essex two wells have been put down, the second one last year and the first one the year before. The first was put down 1,230 feet and struck oil at 1,210. In the second we got oil at 1,210 feet and the oil rock between 1,245 and 1,280 feet. There is 116 feet of drift on top of the rock there, below which is the limestone, but there is no soapstone. We thought we struck Corniferous limestone. The formation seems to be the same as in Ohio. I think we went through the Niagara formation about 600 feet. The first well is on the Lalonde farm about a mile north of Comber; it pumped about fifteen barrels the first day, and then fell away to two or three barrels; we pumped about a hundred barrels out of it. They claim now that it is flowing about half a barrel a day. The second well was about 500 yards north of the first, and was not as good. Stone like Utica slate was got out of the first well when shot. We got bitter water at 230 feet, salt water at 720 feet and then shales and streaks of limestone from that down. We got some gypsum below the bitter water I think. We struck some surface oil at 230 feet, at 270 feet we got another show, and at 608 feet we put in the casing.

Wells in the Oil Springs territory. On the 1st of July last there were 964 wells at Oil Springs. They are located on lots 16, 17, 18 and 19 in the 1st and 2nd concessions of Enniskillen; 258 in the 1st and 706 on the 2nd. The product at the present time is about 20,000 barrels a month. The burning oil sells for about 14 cents per gallon, the gas oil for 7 or 8 cents, and the tar is worth 75 cents a barrel; the coke does not count.

J. H. Fairbank—I came to this country in 1861. In 1859 or 1860 the first attempt was made at utilising Canadian petroleum. The first attempt consisted in extracting a liquid from the "gum oil" that found its way to the surface at what then was known as the "gum beds" at Oil Springs.

The first development at Oil Springs and Petrolia. Then surface wells were dug to a depth of 40 to 60 feet; they were not flowing wells. Near the surface rock was a bed of gravel, and on reaching that the oil would press into the well and raise it quite a number of feet. The surface well was usually a shaft of four or five feet in diameter. That was done both at Oil Springs and here, and was the first development. The first drilling in the rock was at Oil Springs, about

1861—and soon after rock wells were sunk here. After a few had been put down at Oil Springs they struck the great flowing region. At that time they cribbed a four foot shaft down to the rock, and most of the drilling was done by hand power. In the winter of 1861-62, flowing wells were struck which produced very largely, some of them reaching into the thousands of barrels in 24 hours. The great bulk of that oil went into the creek and was lost. Quite a number of such wells were put down, and I think at one time there must have been twenty flowing wells; there was hardly a pump operated. The price of land went up, but there was nothing like the excitement that occured subsequently. It was then twelve miles to the nearest railway station at Wyoming. There was navigation, but it never amounted to anything except one season when a few thousand barrels were floated down. A plank road was built to the railway and the oil went that way. Between the striking and the controlling of the flowing wells there was a period of great waste. I think these wells did not continue more than two years after they were struck; they changed to pumping wells, the supply seeming gradually to become exhausted, and water took the place of the oil. Between that time and the end there were two periods of excitement, and some years after that Oil Springs became practically deserted. About 1865 developments were made at Petrolia within the present corporation, but no flowing wells were struck till a later period. The flowing well period in Petrolia was about 1866; that was in what is known as the King district, a little west of the present town. We have had wells there as high as 400 barrels a day. At Oil Springs the flow was very much stronger; I think the Black and Matheson well at Oil Springs flowed as much as 6,000 barrels in 24 hours. I made a calculation at the time, and it was about that. That great flow was only of short duration, lasting a few days till it was controlled. Here the greatest flow was from 400 to 800 barrels, and not much was wasted. These wells continued to flow a good while, and then it became necessary to pump them; some of them are pumping wells to-day. Some small flowing wells were found beyond the King district, but that was the great centre. Flowing wells were generally found where there were crevices. At Oil Springs at 370 feet they struck a great crevice. The production is now gradually falling off; new wells have to be sunk all the time. I would estimate the number of new wells last year here and at Oil Springs at 400. Wells are not abandoned till the production falls to a few gallons. The cost of sinking an ordinary well in the old days, after the machinery was ready, was about $1,500. The contract price was generally about $3 a foot for the first 500 feet, and it usually took about three months to put down a well. That of course cheapened till now the price for sinking a well is about $150 or $160. I have not known it less than that at Petrolia. At Oil Springs it is less on account of the depth being 100 feet less than here; the depth of wells there is 370 feet. I do not know why it is less than here, as the formation is about the same. I do not know how many wells were abandoned last year, but I do not think there were as many as 400. Some are being constantly abandoned; in some instances they are allowed to stand, but in others the tubing is taken out. There are now no large wells at all. The system of working a number of wells from the one engine, the jerker system, came in as the production fell off. When we had large wells we would abandon a well that produced only five or six barrels a day; now the man who gets a well of that kind is considered to strike it rich. The jerker system was adopted about twenty-five years ago. I remember the time the first jerker was put into operation. It was not patented, and I do not know that it could be. I had a well too hard to work by man power; I hadn't an engine, but there was engine power within reach and I applied the present jerker system. I think that was in 1863. The majority of wells were then worked by man power with a spring pole. The jerker is universal now, and it would be impossible to work upon the old system. It was first used with a horizontal walking beam, that was afterwards improved by using the wheel, with which there is a great deal less friction. I think Mr. Reynolds was the first who introduced the wheel; he is still here. With one engine now they work from half a dozen to eighty or ninety wells, with one boiler but often two engines. I do not know how many owners of oil properties there are. There are some who have two or three wells in their back yards, and some have up to one hundred in a group. The thicker the wells the sooner they will play out. We have instances here where the oil supply was coming from a distance—a producing well being tapped by another a distance of half a mile away, thus showing the connection between the two. There is no indication of the oil coming from a bed lower down, because when we go lower down we do not find it. I do not think we have any producing wells below the depth of 500 feet. We

Flowing wells at Oil Springs.

Flowing wells at Petrolia.

The cost of sinking wells greatly cheapened.

Abandoned wells.

The jerker system of pumping wells.

Groups of wells.

The petroleum bearing rock.

find the oil in the oil-bearing rock, which is a soft porous rock varying in thickness from one to five feet. I understand the Ohio oil is said to be in the Trenton. Our deepest boring here was 1,500 feet, but I do not know whether they came to the Trenton or not. I think the oil is on a certain saturated area, and not that it comes from below at all. At one of the natural springs at Oil Springs they found fine sand all the way down to the bed rock. We have to be very careful about going below the porous rock, as we get into water. After finishing a well now we put in eight quarts of nitro-glycerine and shoot it off. Below our formation we have 100 or 200 feet of salt. It is said to have been found at Glencoe at 1,200 feet.

The salt deposit.

Here we struck it between 1,100 and 1,300 feet, but we have not got sufficient water to work salt here. The first refinery was established here, I think, in 1861 or 1862—one of the first refineries in the country and before any were established in London.

Refineries.

The Great Western railway was built to Petrolia in the winter of 1867-68. Before that time the crude oil was hauled to Wyoming over the plank road. There were refineries at London before the railway was built to Petrolia. There was a period during which we were exporting heavily, and during that time there would have been more refined. In 1870, 1871 and 1872 I think we were exporting heavily,

Export trade.

nearly altogether to England, but the Americans drove us out by producing better and cheaper oil. They can produce a cheaper oil to-day. The great point in their favor is that they have a better crude for illuminating purposes, nearly free from sulphur. They have a superior raw material, but for lubricating purposes ours is fully as good as theirs, and we can produce as cheaply. At the present time the United States ships largely to England. If England allowed us 10 per cent. advantage it would give us a large trade if we had the quantity to supply them, but I think our supply is limited here. I was never interested in Bothwell ; at that place

The Bothwell oil district.

operations were carried on from 1860 to 1865. The surface oil was known for many years and was gathered in the early days as medicine. There is oil in the Bothwell district in different places in small quantities still but drilling has not shown that it is in paying quantities. I do not remember the depth at which oil was struck there, but I think it was 200 feet or more. I do not think there is any chance of the industry being revived there at the present price. They stopped producing when oil was worth $3 or $4 a barrel. The highest price reached here was $10 a barrel—

High prices of crude.

that was in 1865. I think it went as high as $11—the highest I sold at was $7.50. At the period of the large flowing wells at Oil Springs it was worth almost nothing, about ten cents a barrel ; that was about 1862. For a short time about 1865 or 1866 it touched $10 or $11 a barrel. The refined oil was then worth 50 cents a gallon. When oil was first found at Oil Springs we were burning whale oil at $1.25 a gallon. There has been recent improvement in wicks, the circular wick ; but as

Oil lamps.

to burners, the old sun-burner is as good as any. There has been no improvement in the ordinary lamp for a long time. The whole population of this town is directly or indirectly employed in the industry. I do not know how many men are employed, but the number is very large. The refining industry has increased very

The oil refining industry in Petrolia.

much within the last two or three years. Nine-tenths of the oil of this country is manufactured here now, and that has increased the number of men employed very considerably. There are large quantities of chemicals used here, our boilers are manufactured here, our stills are made here, and our brass goods are partly manufactured here. All our engines are manufactured in Canada. There is very little pipe manufactured in Canada ; there is only one manufactory where it is made, and that is in Montreal. They do not make the kind of pipe we want. All material that enters into consumption here has to be of the best quality we can get. It is owing to that and the skill of our drillers that Petrolia men are in demand all over the world. Parties are going out every month. We have drillers now in Germany, Austria, India, Burmah, Mexico and Australia. They are in demand in Pennsylvania.

Petrolia drillers in demand over the world.

I do not know how many gangs are engaged in that industry ; I think more than a dozen have gone away within a month. The cause of the demand is that they have superior tools and possess superior intelligence. Our manufacturers of tools have succeeded in getting the greatest possible strength within the smallest limit, and the training here makes the men perfect in their department. When they come in contact with any of the European drillers they distance them completely. The men are largely the sons of settlers and people who drifted into the oil business. The work is very hard, and requires a strong frame and a clear head. Our men become great experts at it. By handling the pole they can tell what is going on down below 1,000 feet as well as if they were there. We drill much quicker than we used to. Wages, except at the time when it was known but to few, remain about the same. A fair driller gets $2.50 a day. When they go abroad they get

good wages, and expenses paid. They are paid by the day in going to Germany, Austria and India. The pay commences when they get there and continues till they reach home ; their expenses are also paid. The improvement in the quality of illuminating oil within the last two years has been very marked ; the improvements have been made altogether by those in the business, very little has been done by chemists or experts.

Inprovements in oil refining.

The Oil Exchange, of which I am president, was organised about four years ago. The object is for buyers and sellers to meet at a certain hour of the day. Formerly the bulls and bears walked upon the streets, and that was not a very satisfactory way of doing business. The exchange has facilitated business.

Oil Exchange.

We had combinations here, but they would generally last for a season and then break up. The first combination was organised with the object of encouraging export, and it succeeded fairly well; it was organised in 1869. We discriminated between home consumption and export prices, and sent the surplus abroad, chiefly to England. Competition would be ruinous ; jobbers would take advantage of that and reduce the price below cost. The price of refined oil has been run below ten cents a gallon, and crude has gone down to fifty cents a barrel ; that is the lowest in modern times. The first combination we had lasted two years. The last one was organised especially to improve the quality of illuminating oil. It lasted eighteen months and ran through its course. A certain quality of burning oil was to be manufactured, and was to be subject to the examination of the board's inspector. The report of the quality was laid upon the table every week and would show one man's oil to be better than another's. This caused a rivalry ; the treaters and distillers were put upon their mettle ; the result was a great improvement in the quality, and it has to a great extent continued.

Trade combinations to encourage export and improve the quality of illuminating oil.

The Americans were giving our people better oil then they were selling at home ; they were our competitors, and wanted our trade. The oil business there is managed by an immense corporation with unlimited resources, great advantages in the way of freights, and its affairs are sometimes legislation, we think. They sent in a good article and it was necessary managed with consummate ability; it controls transportation and tankage, and that we should meet them. The sharpest competition is on the eastern coast ; there the freight on the American oil is very low, while we have 1,200 miles of railway. Having that advantage there they push us very hard, and they also make a great push for Manitoba and British Columbia. Competition presses hard upon the frontier, and it is difficult to do anything in the Niagara district, though we send our best oils to those districts. We manufacture oil now that is as good as their best, and superior to their ordinary, and to what they use at home. We do not have the trade test now, and I think oil sometimes comes on the market that would not have passed our inspector. I do not think the Government should deal with matters of quality ; that is an affair between the buyer and seller.

Competing with the great United States combine.

I think sulphuric acid could be made in this country and used in the manufacture of superphosphate. The sulphuric acid has been sometimes recovered here. We have sent a good deal of our spent acids from here to Detroit to be used in making fertilisers in connection with the bone phosphate. For our purposes sulphuric acid made from pyrites will answer equally as well as that made from brimstone. A very considerable quantity of acid is used here.

Sulphuric acid.

We make as good a lubricator as ever was manufactured. I have used it for five or six years, running engines, and they have required no repairs. I prefer it to the best lard oil. I supply it to the lake Superior steamers, and they find they can use it in their steam cylinders.

Lubricating oils.

H. Kittridge—I am a member of the firm of McMillan, Kittridge & Co., and superintendent of the works. I have been in the oil business in Canada since 1865. I first located in Bothwell during the excitement there, stopped there a few months and then went into the contracting business putting down wells. I came to Petrolia in 1866 and drilled for two years. There was no cribbing done in my time ; the surface stuff was bored with an auger as now, and there has been no change in that respect. We considered then that twelve or thirteen days was particularly good time, working night and day, and that with the same number of men as now. At that period the greater part of the drilling was done with the cable tools, which system requires only four men to run night and day. That system is entirely done away with in Canada ; ash poles with joints are entirely used. In using the poles it takes longer to clean out the hole at a great depth than with the cable system.

Well-drilling at Petrolia in 1866.

In the winter of 1866 I drilled the well known as the Lancey No. 1. It was drilled with cable tools, and in drilling it we raced with a gang using the pole tools ; we drilled 530 feet and they drilled 30 feet less, but we beat them. Their gang was considered the best in the community. Our time was fourteen days.

The Lancey well.

After the well was down it was offered to me for $50 and I refused it; two days after it pumped 400 barrels a day. It has been abandoned quite recently on account of having too much water. I was never engaged in the tanking business, and I did not go into the refining business until 1878. My first experience in refining was at Oil Springs. I started up the old refinery during the existence of the combination and continued there about nine months. That refinery must have been built in 1863 or 1864. At one time there were six refineries at Oil Springs; that would be between 1862 and 1865. In 1867 the last one shut down. They shut down owing to the failure of the supply of the crude material. A large quantity of crude oil went from Petrolia there to be refined, but everything was on a very small scale then. Our present works were started in 1880. We are working under a patent process which stands in my name. Mr. Woodward has a patent which is about the same as mine. The best way to explain the system will be to read the patent. It is as follows:

Refining at Oil Springs.

Patent process for refining crude.

I am aware that the present ordinary method of refining illuminating petroleum is to treat the distillate obtained by the distillation of crude petroleum with sulphuric acid, caustic soda, litharge and the flowers of sulphur. In such method the distillate is first treated with the sulphuric acid to remove the tar and other impurities that may be affected by the acid. Then after being washed with water, caustic soda is used; and in order to deodorise the oil thus far treated the litharge is added. Then in order to precipitate or settle the litharge or other impurities, or compounds of said chemicals, the flowers of sulphur are added. But oil so treated gives off an offensive odor when burning, always smokes the lamp chimney and crusts the wick; which defects I claim are removed by my process. In my process, take the distillate obtained as aforesaid, treat it in the ordinary way as before specified up to the point when the flowers of sulphur would be added, but do not add the flowers of sulphur. Then at this stage of the treatment return the oil thus treated to the still and re-distil it. The distillate product of this redistillation is then to be treated in the ordinary method as before specified, with sulphuric acid, caustic soda, litharge and the flowers of sulphur.

When we put the lead in our oil to treat it, it combines with the sulphur, the color is changed, but the lead remains in the oil and cannot be got out. Then we put in sulphur and that leaves the oil light and clear. We have rendered the oil sweet to the nose, but the sulphur is there and as soon as we burn the oil we have the bad odor and the smoking of the chimney. By my system the sulphuric acid, lead and sulphur are extracted. There is a little sulphur left, but it is much better than the old system. We have not got a perfect system, but we have improved upon the old, and it is good as far as it goes. We make very fine oil, and the Americans have to send their very best oil, to compete with our improved and to hold the market. We have three large stills, and one re-distilling still. The capacity of our three stills is 300, 275 and 250 barrels. We make two runs in the week, but we could if necessary make three runs in that time. As we make mostly an extra good illuminating oil we get a small percentage from the crude. The first product is 74 naphtha, 62 benzine, then the Water White illuminating oil; we make four grades of burning oil. The specific gravity of our Water White is .788. We make a special oil for Rogers of Toronto, the Carbon Safety, gravity. .796. Our third and standard brand is .802. We make a neutral oil of .850 gravity; that is used mostly for wool and for adulterating all kinds of oils. We make paraffine, but not extensively, besides various kinds of machine oils. Our market for illuminating oil has extended this year from the furthest points in Manitoba and the North-west territories to New Brunswick—generally speaking all over the Dominion. The demand for our Water White is increasing. Our oil has been handled altogether this year by Samuel Rogers of Toronto; we have not therefore solicited outside orders. Some of our oil is shipped in tank cars and barrelled in Montreal. At the present time we employ eleven or twelve men. There are three yardmen, one treater and his assistant, and two stillmen. I have no man working less than $9 a week. The treater and stillmen are getting $2 a day each, and the coopers get $2 a day at this season.

Capacity of the refinery.

Grades of oil produced.

Markets for the illuminating oil.

Workers and wages.

James Kerr—I came to Petrolia in March, 1862, and have been in the country constantly since. During that time I have been connected with the oil business, experimenting, operating, putting down wells, building refineries, etc. I have paid a great deal of attention to the quality of the oil. As compared with the Pennsylvania oil, ours is composed in great part of a different series of hydrocarbons; therefore the chemical affinity of our petroleum with foreign mattter is greater than that of the Pennsylvania product. The paraffine series of hydrocarbons is less liable to unite with foreign matters; it is not easily affected with sulphur, sulphuric acid, chlorine, or anything of that kind. The paraffine series of hydrocarbons is that which obtains in Pennsylvania, and is more truly developed there.

Quality of the Ontario compared with the Pennsylvania petroleum.

I think that quite an amount of ours may be classed as olefines, and some other series of paraffine described in our books as iso-paraffine, and neo-paraffine, and the different series of hydrocarbons. The petroleum here is not as complete a series of paraffines as that of Pennsylvania, and it is more contaminated with sulphur. I think it might be called an abnormal series of hydrocarbons. It is chiefly the sulphur that is troublesome. These hydrocarbons being different from the normal hydrocarbons, they are more difficult to treat. One of the characteristics of this abnormal series is the facility with which it unites with foreign substances ; here it is largely contaminated with sulphur compounds chemically united with the hydrocarbon molecule. I would not call it sulphuretted hydrogen in its natural state. The fact of these hydrocarbons being different from the normal renders them difficult to work. When they come in contact with our chemicals they are liable to combine and form compounds that do not vaporise and oxidise in the flame as the pure series of paraffine hydrocarbons do. It makes smoke and causes a deposit on the wick unless these impurities are removed. In Pennsylvania they do not have that to contend with. We get a great deal of lubricating material out of this crude oil. Our lubricators are as good as any, and we can make any variety or grade we choose. I think they can do the same in the States, but I think we get a larger percentage out of the crude. There is only a certain proportion of our oil that is valuable for illuminating, at any rate in the present state of the market, but on the other hand there is a larger portion here of the lubricating series than in Pennsylvania. In addition to the illuminating oil the products are gasoline, naphtha, the intermediate and wool oils, as many grades of lubricating oils as desired according to the point at which distillation is stopped, and after that we have paraffine wax. The wax is used for making candles and different other purposes. In addition there is the coke, but that is only used in the house for fuel. In the early days we had analyses made, but we found them of no practical value; they are reported in the chemical dictionary published by Lippincott, and are referred to in the British Encyclopædia, ninth edition. In the process of manufacture the gas escapes ; it could be utilised for fuel, but we do not require it, as we have the tar and refuse. There would be no difficulty in saving it. Vaseline is nothing more than the heaviest grade of lubricating oil. Our crude is said by some analysts to contain some of the compounds that are used in the manufacture of the aniline dyes, but it is not considered as good a substance as coal tar to produce dyes from, and we have never manufactured any. Tars and asphalts could be made from the oxidised matter that is got in the treating process. Asphalt is very largely used in this country for roofing, and is imported. If there were sufficient demand for that or any other product that we could possibly produce, we would turn our attention to it ; but we do not make anything till it is called for. In reference to the refining of the oil, my observation reaches back to the early part of 1867. The old process was then used, the same as now obtains in Pennsylvania. It is simply the separation of the different gravities by distillation, and the treatment of the distillates with sulphuric acid and caustic soda ; that is to take out any of the depraved matters formed in the distillation by the cracking of the oil molecule. We take out the broken carbonaceous matter ; that is the whole process in Pennsylvania. In 1867 that was the process here. In 1868 I went into the refining a short time at Oil Springs, and about that time the lead treatment was introduced, I think by Mr. Allen. He was an Englishman who came to this country and introduced the system ; it was stolen from him and he never got anything out of it. In the early days at Oil Springs a great deal of attention was paid to chemical analyses. An old Scotchman connected with the Canada Rock Oil Co. named Pearce, I think, did a great deal of work, but he took ill and died, and the results of his labors were lost. He made some good samples of oil. From 1868 to 1885 there was no improvement in the treatment of our oil. At that time the system of redistillation described by the last witness was introduced. The process of redistillation takes about 24 hours for our large stills. It consists simply in distilling the oil off the sulphide ; before the distillation it is translucent, showing the sulphur is in solution ; translucency shows perfect union. The objection to the new process is the increased cost of the redistillation, but if properly done the product should be perfect. I think the flash test should be 73 instead of 95, and that the gravity should be changed from .805 to .807. The American oil on account of its composition is liable when exposed to a low temperature to crystallise. When crystillisation occurs a separation takes place of the gravities and boiling points, and when drawn from the barrel we get simply the oil with a very low flash point, leaving that with a high flash point in the barrel. Our

Difficulty of treatment.

Lubricating and illuminating oils.

Other products.

The old process of refining.

The lead process.

The redistillation process.

The flash test.

oil does not crystallise at anything like the same temperature. It would be easy to provide different tests for the American and Canadian oils. With a lower flash test, instead of being able to get 9 per cent. of Water White we would be able to get about 12 per cent., and that would put us in a position to compete with the American oil very much better than we now can. In New Jersey and the eastern states the flash test is 63; in New York state, for the English market and for most foreign countries, the test is 73; in Michigan, Minnesota and Indiana they have about the same as we have. The result is that the Americans have a market for one part in New Jersey, for another in New York, and so on. The reason the gravity was restricted was because the oil was made very heavy, with the result that when exposed to cold there was crystallisable wax in it, and this rendered the fluid parts of different flash tests when drawn off. In our oil now there is no crystalli ation even in the co'dest weather. Take the best American oil and you will see the paraffine wax at 10° below zero, while ours will not show it even at 40° below zero. The gravity of our best oil is .788, and the American is very much the same. In distilling the heat is applied gradually to the crude oil. We do not know the degree of heat when it begins to distil, but I think it is anywhere from 200 to 800°. It commences below the boiling point of water, or about 200°; we increase the heat as we get down to the heaviest oils, and before we are through we have the bottom of our still red hot. I think we can take the boiling point of the extreme end of our burning oils at 400°. The average would be a great deal less than that, perhaps 270°, while the lightest would not be more than 200°. Some of the gasoline would pass off at 90° or 100°.

The specific gravity.

Temperature of petroleum in the process of distillation.

R. E. Menzie—I am the manager of the Producers' Oil Refining Co., organised in the fall of 1884. The subscribed stock is $50,000, on which is paid up $37,998. A. C. Edward is president and there are fifty shareholders in the company. We are not as a company producing crude oil. We have eight stills, six of which run continuously on the crude oil; the other two are used for the double distilling. Last year we put through 105,000 barrels of crude, making 42,000 barrels of refined oil. Our products are refined oil, gas oil, tar and coke. We make one grade of refined. called Union. The average price of the oil without the barrels is 8 cents an imperial gallon. We produce benzine which we sell at $7\frac{1}{2}$ cents a gallon, including the barrel; that leaves $4\frac{1}{2}$ cents for the benzine. We are sending a low gravity gas oil to St. Hyacinthe and Sherbrooke, Quebec. Tar is worth 70 cents per barrel in bulk, and we made 21,000 barrels last year. We also made 15,750 barrels of gas oil and about 210 loads of coke, which we sell at about $1.50 a load. Our illuminating oil goes from the Atlantic as far west as Brandon. We have shipped the tar to different places around the country—to Courtright, Goderich, Ingersoll and St. Thomas; we don't export any of it. We employ 16 or 17 men; sometimes as low as 7 or 8, and sometimes as high as 30. There are two stillmen at $2 a day, two engineers at $1.50 a day, one treater at $21 a week, three coopers at $2 a day, two painters at $1.75 a day, and ordinary laborers $1.50 a day.

The Producers' Oil Refining Co.

Annual product of the refinery.

Markets for product.

Labor and wages.

James Fides—I am in the employ of John McDonald, oil refiner. Our works were established in May, 1882. Besides being engaged in refining, Mr. McDonald is a producer and farmer. He has forty or fifty wells, two of which are near the distillery; the others are mostly on his farm on the 12th line of Enniskillen, about a mile and a half from the refinery. These wells yield a pretty fair average; I suppose they will go a barrel a day. Some of them at first pumped 100 barrels a day, but that is some time ago. He put down 25 upon his own place this year, and the highest he got from one of them was 10 or 15 barrels a day. We produce three grades of illuminating oil, Acme .790 to .795 gravity, National .802, and Safety .802 to .805. Formerly we manufactured but the one brand; we commenced to manufacture the three brands about six months ago. We manufacture wax, paraffine oil, and candles; also axle grease, wool oil, machinery oil, benzine. gas oil, black and other grades of lubricating oils. There are eleven men employed in the refinery. The two running the stills get $2 a day, cooper $2 a day, candle-maker $2 a day, and others get $1.50 a day. Our market is all over the Dominion of Canada. We export the wax to Scotland *via* New York over and above what we use.

McDonald's refinery and wells.

Products of the refinery.

Wages.

Market.

Frederick Wolfe—I am the manager of the Consumers' oil refinery, which was erected in 1881. The capital, all paid up, is $30,000. We have five stills for burning oil, and two paraffine stills, making seven in all. Our stockholders are producers, but the company is not. During last year 48,799 barrels of burning oil of two grades were manufactured. We have half a dozen different brands, but there are only two grades, the Water White and the Prime White. The brands of the Water

Consumers' oil refinery.

Products and bye-products.

White are the Beacon Light and the Brilliant Light. We make paraffine wax, paraffine oil, benzine, gas oil, neutral oil, and oils of different kinds for machinery. For manufacturing the Water White we have a process different from the other refineries. We don't use lead or sulphur in the treament; we use chemicals in the still. We manufacture under Kennedy's process. What we have done so far that way has been experimental. We put into the distillate in the still an equal quantity of caustic soda of 60 per cent. strength and copperas and common salt—about half a pound of each to the barrel of oil. That produces an oil that does not require the other treatment. We are positive that we can manufacture oil without lead. It does away with the sulphur to a great extent and stops the crusting of the wick. Our market is from Halifax to western Manitoba. We have not supplied the North-west lately. I think the Imperial Oil Co. stores oil in Winnepeg during the summer and they get lower rates that way. Without having a storehouse there we cannot supply that country in the winter on account of the high rates of freight. Benzine is sold in Ontario and Quebec, but our different kinds of lubricating oils we sell all over Canada; we do not export any. The Americans compete with us in lubricators. The best grade of American oil has no sulphur. We have not altogether got rid of the sulphur, but I think our process will to a great extent. We employ about fifteen men here; two stillmen at $1.75 per day, one treater at $2, two coopers at $2, one painter at $1.75, and men around the yard at $1.50. We run the stills night and day and make two charges a week. During the very cold weather we shut down for about two or three months, and I think most of the other refineries do the same to a certain extent.

The Kennedy treatment.

Markets.

Rate of wages.

John D. Noble—I am an oil operator, one of the earliest as far as Petrolia is concerned. I came here about 1866. The way my attention was first called to the business was this: I was a vessel owner residing at Kingston. A schooner came back covered with oil and I asked the captain what was the cause of it. He said they had struck oil at Sydenham and could not stop the wells flowing, and that it was coming down the river a foot thick on top of the water. I considered there might be something in it, so I came here immediately to look into the matter. What the captain referred to was caused by the flowing wells of Oil Springs. When I got here they had just struck oil at Petrolia; I fancied the place and bought some land. Just at that time the King flowing well was struck, and I bought some property close to it, and put down a well which pumped 260 barrels a day. At that time oil was worth $1.25 a barrel. I sold as quickly as I could, but I had to erect a number of large tanks on the ground to store in till I could sell, so that my land got pretty well covered with large wooden tanks. A fire broke out on the adjoining property, extended to mine and burned all my tanks and some 7,500 barrels of oil. The fire extended till it covered some twelve acres. It lasted two weeks, the flames shooting up 100 feet. That was in 1867. I thought over the matter how a recurrence of such a fire could be avoided, and I devised the tanking system. I considered the matter over with some friends, Mr. Jenkins in particular, and we decided to adopt the present underground system. The clay here is of such a nature that it makes a perfect tank in itself. We formed the Petrolia Crude Oil Tanking Co., and elected Mr. Jenkins president and I was elected vice-president. The company was incorporated under the Joint Stock act of Ontario. On top of the clay there is an alluvial deposit of about 15 or 18 feet. Excavations are made about 60 feet deep and 30 feet in diameter, with a capacity of 8,000 barrels of 35 imperial gallons. When we get down 18 or 20 feet, to the clay, a wooden sheathing is put round the tank, clay is pounded down firmly, and the wall is brought up about a foot above the surface. At the top it is sloped off so as to prevent water getting into the tank, and it is perfectly water-tight. I have held oil in my tanks for ten years without leaking a drop. If the tank were empty the pressure from the outside would be considerable; therefore we always keep them full of water or oil. There is no planking on the bottom; the oil is poured in on the clay, which continues for about 100 feet. To build an 8,000 barrel tank costs about 25 cents a barrel or $2,000 for each tank, but sometimes we get it for 23½ or 24½ cents a barrel. Refined as well as crude oil can be stored in these tanks. The temperature is always the same, and there is no danger from lightning, which is the great cause of fire. Our company have about fifty tanks, with a capacity of about 300,000 barrels. Pipe lines are laid all over the territory, so that producers are enabled to pump their oil to our receiving stations, and they get our receipt for the amount pumped. We have receiving stations in the township of Sarnia, and at Marthaville, three in the Petrolia vicinity, one at the east end, one at Oil Springs. When it is delivered by the pipe line it is

Early experiences at Petrolia.

The underground tanking system devised.

Construction of tanks.

Collecting and storing the crude.

pumped into a wooden tank that holds so much to the fo t. Where producers are not connected by the pipe line they employ wooden tanks which contain eight barrels each, a teamster brings it to the tanks and it is placed to the credit of the producer. Our receipts are very much the same as warehouse receipts. The holder if he desires can take them to the bank and money will be advanced on them freely; or he can sell his receipt to a refinery, which calls upon us for the delivery of the oil on demand. As soon as demanded we pump it to the refinery, and we are connected with all the refineries. As we pump the oil out we let in water below; that forces the oil up, and keeps the tank full. A cent a barrel a month is our charge for storing. Our tanking company is separate and distinct from the others. The average production of the wells now is about a half a barrel a day; we have some that pump as much as nine or ten barrels a day, but half a barrel is about the average. I think the largest well we have is about ten barrels a day. The price now is $1.11 per barrel. The principal reason that we cannot compete with the Americans in the English market is that they produce about 75 per cent. illuminating oil while we produce only about 40 per cent; their wells flow as high as 2,000 and 3,000 barrels a day, while ours average only half a barrel. For these reasons we are confined entirely to Canada, and were the American oil allowed free into this country our industry would be completely wiped out; we could not compete with their flowing wells. They sell Prime White at 7 to 8 cents the wine gallon by the car, and Water White at 10 to 12 cents. Having regard to the difference between the wine and the imperial gallon (one-fifth) that would be equivalent to 8½ cents as against 11 cents. We have a refinery in connection with our business, but we only make one quality of oil; it is between a Water White and a Prime White. In the States they make two qualities, Prime White and Water White. Their Prime White is nearly as good as our Water White, about as good as our firm makes. In former years the Canadian manufacturers did not give the same attention to the business as now; we now make a much better oil than formerly, but we suffer from our bad reputation. In our refinery we use 50,000 barrels of crude oil a year. We take 40 per cent. of that as burning oil; the balance is composed of gas oil, lubricating oil and tar, and there is a loss of about 10 per cent. The tar is about 20 per cent., gas oil 15 per cent. and lubricating oil 15 per cent. We ship most of our refined oil in bulk to Ottawa and it is barrelled there. The average value of our burning oil would be two-thirds at 8 cents, and one-third at 11 cents, making about $63,000 for the year's product. The gas oil is worth 75 cents a barrel of 35 imperial gallons, the lubricating oil 5 cents a gallon in barrels, and the tar 70 cents a barrel in bulk. The capital of our company is $50,000, all paid up. From the 20th January to the end of December, 1887, we received 244,979 barrels and shipped 360,309 barrels. In the ten months of 1888 we received 231,636 and shipped 206,893 barrels; in 1884 received 255,768 and shipped 184,214 barrels; in 1885, received 299,407 and shipped 312,554 barrels; in 1886, received 253,022 and shipped 240,134 barrels. The consumption of refined oil has been increasing, but the supply of crude oil has been diminishing.

Supplying the refineries.

Average production of wells.

Why Canadian cannot compete with United States oil in the English market.

The Petrolia Tanking Co's refinery.

Tanking statistics.

William Hammond—I am connected with the Producers' Tanking Co., which was organised in 1884 as a joint stock company under the Ontario act. The subscribed capital is $40,000; the paid up capital is about $24,000. Our tanks have a capacity of about 82,000 barrels. We have about five miles of pipe line running around the corporation east and west, and get our supply from the Petrolia district altogether. We have eleven wells of our own that pump about 250 barrels a month. Our charge for storage is one cent a barrel per month. We send a little crude to London and Hamilton, but not much—nearly all is used here.

The Producers' Tanking Co.

Duncan Sinclair—I am a well driller and have been drilling wells for seventeen years for myself. I have been drilling altogether for about twenty years. I drilled for a year and a half in Italy for oil, and I have also drilled in New Brunswick. When I first started we drilled with the cable drill and worked night and day with a gang of four men. Now it takes three men for the night and three for the day. We use white-ash poles about 36 or 37 feet long, spliced in the middle. We cannot take them out as quickly as the cable. When I began work twenty years ago the first well I worked at took five weeks to finish after we got down to the rock. Going down through the surface was another branch of the business; the surface was put down with an auger. Drillers were getting about $2.50 a foot for drilling surface and all. The contractor took the job and let the surface boring; he did not furnish rigging at all, nor the wood nor water—only the boring tools—and it took four or five weeks to put down a well. There were very

Well-drilling with cable and poles.

few poles used then. The cable tools were lighter than the cable tools used now, but of the same style. The advantage of the pole is that you can hold the tools together going through any difficult or bad rock, when you could not with the cable. We get oil here at from 450 to 465 feet. I have never found much oil below that. We can put down a well in a week now, or perhaps in less time if we have no breakage; sometimes it is done in five days, but as a general thing a well in a week is fair work. The price is now $150 to $160 a well, and we supply the tools and machinery, and wood and water if required. We drill in a dry hole, putting in enough water to rise to the depth of the sinker; the tools drop very fast. The weight of the sinker is 1,000 pounds, much heavier than it was in the old days. Now we know how to run to perfection, while in the old days we knew very little. There are gangs constantly drilling here, but in the whole region there used to be a great many more than there are now; they have gone to foreign countries. The casing is furnished but we generally put it down; we put down the pump and just start it; of course that is also furnished. I think about ten or twelve gangs are employed around here. A great many of our drillers are in foreign parts; the Canadian drillers have a good name, and they are sent for. A great many are going from here to Australia, and I am going myself too.

Drilling by the present process.

Petrolia well-drillers abroad.

W. Gibbon—On the south side of Manitoulin island, east of Manitowaning, a company bored for oil. They got petroleum, but had to desist on account of the amount of salt which prevented further work. It is about twenty years since the work was done there. They bored I think in three or four places, one well being sunk to a depth of 400 feet, and the others 260, 320, and 160 feet respectively. The oil in each of the wells was of superb quality, but in each case they also met with salt.

Oil in Manitoulin island.

PHOSPHATE OF LIME.

The Commission visited several producing properties of apatite or phosphate of lime in the Kingston district, along the line of the Kingston and Pembroke railway, and also in the Perth district in the vicinity of Otty and Bob's lakes. This latter country was thoroughly described by Mr. Vennor in the report of the Geological Survey for 1873-74, pp. 100-139. Though only a small part of the phosphate-carrying districts was visited by us, enough was seen to prove conclusively the mistaken idea which seems to prevail in some quarters that phosphate of a lower grade, or of an inferior quality, alone exists on the Ontario side of the Ottawa river. Larger deposits have been opened up, particularly in one district, on the Quebec side thus far, but as regards similarity of occurrence and variation in quality (dependent largely upon intelligent dressing of the rock) identical conditions appear to prevail on both sides of the Ottawa. The quality of the higher grades of phosphate shipped from some of the mines along the Kingston and Pembroke railway is as high as any produced in Canada. The evidence will point out various facts in this connection.

The phosphate regions.

The phosphate properties of Capt. Boyd Smith are on lots 29 and 30, concession 1, township of Hinchinbrooke, in the county of Frontenac. A wide band of grey pyroxenic rock strikes north-east and south-west and dips to the north-west. On the north-west side is crystalline limestone, and on the south-east side granite. Magnetic iron ore occurs in places in this formation along with apatite. The veins or deposits of apatite occur irregularly in various sizes and striking in different directions. About twenty openings have been made from 20 to 60 feet deep. One large opening from which phosphate has been taken to a depth of 140 feet shows a width of from 12 to 15 feet, while another large bunch has been worked down to 145 feet. In places the pyroxenic rock becomes very quartzose and resembles gneissic quartz syenite. The

The Boyd Smith mines.

phosphate is mixed with black pyroxene and magnetic iron ore. The grey pyroxenic gneiss gives place to a pinkish syenite in places, and when this occurs the phosphate, where found, is of a pinkish color. Another large surface deposit of red phosphate runs north-east and south-west and is about 8 to 10 feet wide. Mr. Smith stated in his evidence that the average of apatite shipped during the past two years is 84 per cent. The magnetic iron ore occurs similarly to the phosphate, and is of a high grade when the apatite is carefully cleaned from it. The bands, however, are not wide enough or apparently presistent enough to make it worth while working them at any places yet opened.

Iron bands.

Foxton mine.

The phosphate property of James Foxton, of Sydenham, is situated on lot 10, concession 13, of Loughborough, in the county of Frontenac, about seven miles from the village of Sydenham. The rock in the vicinity of the deposit is a banded gneiss with grey hornblende and pink felspar seams, quartzose in places. At the bottom of the largest pit (Fig. 28) the strike is north-east and south-west, but the width is not known as the wall has not yet been reached on the south-east side. At the two ends masses of dark green apatite and pyroxene are exposed to a width of 12 feet, and on the south-east wall is a quartzose hornblendic rock. The phosphate in this deposit is pure and of very high grade. On the surface the vein can be followed for some distance. Another smaller pit has been sunk on this vein near the shaft, where calcspar is found full of phosphate crystals and associated with some mica crystals. It is said this vein can be followed across the lot. About 100 yards north 55° east from the shaft, at another opening on the same vein, there is a pit 25 feet deep, the vein dipping 75° to the north-west. It yields at this place a great deal of pyrites, the vein consisting of two feet of phosphate and four feet of iron pyrites across its width.

S.W. N.E.

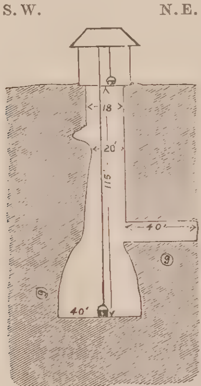


FIG. 28. Foxton mine. *g. Phosphate and pyroxene.*

Otty lake district.

Several openings were visited on lot 4, concession 8, in North Burgess, on the shore of Otty lake. At the first opening visited (Fig. —) the phosphate runs east and west. At the second place there is a vein of phosphate four or five feet wide dipping to the east and nearly perpendicular, consisting chiefly of layers of phosphate and mica. One of the layers is two feet in thickness and will run 80 per cent. of pure green phosphate. A shaft has been sunk here to a depth of 100 feet. The walls are a grey quartzose granitic rock, and in places vein stuff is mixed with pyroxenic matter. Through this part of the country the phosphate occurs in narrow veins or deposits in a pyroxenic micaceous rock with quartz patches in places. There does not appear to be any large masses of apatite in this township, and it is said that it is found more profitable to carry on a number of small workings, as open cuts or excavations, with a few men, than to try deep mining with hoisting and pumping machinery.

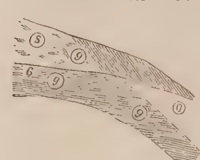


FIG. 29. *g. Phosphate and mica. o. Quartz. s. Quartz and felspar.*

SUPERPHOSPHATE WORKS AT SMITH'S FALLS.

The Commission visited the superphosphate works of the Standard Fertiliser and Chemical Company, Smith's Falls, and as the subject of fertilisers is of especial importance to the agricultural industry of the country some facts from Mr. Brodie's evidence are taken, together with information derived at the works themselves, to make the description of the process and resulting fertilisers more complete. Various grades of superphosphate are manufactured for fertilising purposes, and acid phosphate is also made at the works which is used for baking powder, etc. The sulphuric acid used in the process at this establishment is manufactured from brimstone imported from Sicily, and costing at Smith's Falls one cent per pound. The apatite is ground very fine by buhrrstones, after which it is conveyed into a vat by means of a fan. The coarser dust falls back to the stones and is re-ground. The apatite requires to be pulverised to such a degree of fineness that if bolted it would go through a 120 mesh, or at least an 80 mesh. The charge is weighed out, moistened with sulphuric acid and run into the mixer, and thence into an air-tight bin that has a wooden funnel above to carry off the hydrofluoric acid which generates. The acid and phosphate of lime work in this bin and solidify in twenty-four hours. It is then broken up by a sort of disintegrator, and after being mixed with various proportions of hydrochloric acid, ammonium potash, ammonium sulphate and nitrate of soda it is ready for shipment. The following grades of fertilisers are manufactured: Superphosphate of lime.

No. 1	$32 per ton.
No. 2, Standard	35 " "
No. 3, Special	40 " "
No. 4, Fruit tree	42 " "
Plain superphosphate	26 " "

In 1887 three hundred tons of fertilisers were manufactured and sold. Acid phosphate is also manufactured by this company. Only the purest ground phosphate is used for its production, which is carefully sorted by hand. After the acid has dissolved the phosphate the charge is leached off and the product is the liquid phosphate. This is then evaporated down to a syrupy condition, is mixed with starch and dried, after which it is ground. It is used as a substitute for cream of tartar, and chiefly as a baking powder. Acid phosphate.

The phosphate used at the works comes from Burgess and from Buckingham. The high grade (83 or 84 per cent.) used for acid phosphate costs $17.50 at the factory, and the low grade (65 per cent.) costs about $9.60. Farmers use about 300 pounds of the fertiliser to the acre, and that quantity is claimed to have the same effect as 25 wagon loads of well-rotted barnyard manure. Market gardeners use 800 to 1,000 pounds per acre. The ammonium sulphate costs $60 per ton, and $11 worth is put into a ton of the fertiliser. This and the potash are imported from Germany. Of the output of the works about seven-eighths is of the grades Special and Standard, and the price obtained averages $35 per ton. The lead chambers in the works cost about $10,000, and the pure sulphur is said to be much less severe upon these than when iron pyrites is used. The sulphur also occupies much less room, and a boy can look after the furnace. The cost of producing sulphuric acid is about 70 cents per 100 pounds. Cost of the fertiliser and its raw materials.

Mining in Storrington.

Joseph Bawden—I have been interested in phosphate property in the township of Storrington on lots 2, 4 and 5 in the 14th concession. I was associated with J. M. Machar and we carried on operations for one winter, and some of the properties we let out to parties on a royalty. No mining has been done in that region within the last four years. We took out about 120 tons of phosphate, and the other parties about 300 tons. The amount of royalty generally depends upon the state of the roads, the distance from a market and the supposed practicability of working the deposits. It varies from $1 to $2 a ton. We sold part of what we mined ourselves at $15 a ton. It has been sold in this city at from $10 to $15 and $16, depending upon its richness and the price at the place of manufacture. The portion we sold for $15 a ton was required to go 75 per cent. By culling, the phosphates of this section can be made to grade up to 80 per cent. All the phosphate of good quality finds a ready market at Kingston for shipment to Great Britain or the United States, to Baltimore. I understand that the demand for Canadian phosphate is increasing considerably in both England the United States. Canadian apatite now forms 12 per cent. of the quantity entering into British manufacture.

Market for phosphates.

The phosphate formation comes into Frontenac county at the north-east part of the township of Storrington, adjoining Leeds, where a large amount was mined for the Brockville chemical works. A large quantity was taken out by Cowan and Steele on the shore of lake Opinicon. Since then James Hunter has taken out considerable quantities. This formation is continuous with the phosphate bearing formation in which Mr. Machar and myself carried on mining. We traced the phosphate bearing formation in a westerly direction from that point across the township of Loughborough, at different points in the 10th, 11th and 12th concessions, to nearly the western boundary of the township ; that is the first belt of the phosphate mining region. Next, going in a northerly direction in Bedford, we find phosphates at different points in the line across the south third of the township, but not passing the western boundary of the township that I am aware of. We have another phosphate bearing formation north of Bob's lake, extending into the township of Hichinbrooke at that point I believe. In one of the bands the phosphate seems to be replaced by mica. In Storrington and in Lougborough we get deposits of mica which are now worked—that is in the first band I mentioned. In some phosphate veins we find black mica.

Belts of the phosphate-bearing formation.

George Richardson—I have seen nearly all the mines in the Frontenac section and have handled the product of pretty much all the phosphate mines in this part of the country. At Sharbot lake there is a good mine belonging to Mr. Smith, who has also a mine near Bedford station. Both are large mines. The Foxton mine is on lot 13 in the 10th concession of Loughborough. This with the two owned by Mr. Smith are the only mines that are working to-day. The output of those three mines is about 3,000 tons a year. There are some small locations worked by farmers, who mine the phosphate in small veins and throw in a lot of dirt with it. In Sebastopol, beyond Bob's lake, there is phosphate, and we shipped a thousand tons out of that section when we worked it. Our property is 6½ miles from Eganville, in Sabastopol, and there is hardly a lot in the township that has not phosphate on it. To the north of Haley station also there is phosphate. We have worked twenty-five or thirty deposits on our property. Phosphate is very deceiving, as it is apt to run out at any time ; that I believe is the case with phosphate in all sections. In some places the phosphates are capped with crystalline limestone, in other places with black jack, and sometimes they are found with pyroxene rock on top. In Sabastopol it occurs as pockets in the limestone. The lime is like a seam on the sides, and when we remove that we get to the phosphate. In the Kingston district we look for it in pyroxene, but in Sabastopol with a lining of crystalline limestone in granite. It is generally found there in a seam, just like a vein, and in s me places wider than others ; there is no greenstone associated with it, and whatever color the phosphate is the granite will be of the same color. The quality of our phosphate is equal to any ; there is no vein in this country that will not run from 75 to 86 per cent. The average cost of mining would be, I should say $5 a ton, that is to make it ready for the market. The freight to Montreal depends upon the locality whence it is shipped ; say from $2 to $5 a ton ; then there is the hauling to the station. Perhaps from most of the mines on the Kingston and Pembroke railway it could be delivered at $2 a ton from the station. For 80 per cent. phosphate we can contract for about $16 or $17 at Montreal. The German market pays the most money for high grade phosphate. It costs Mr. Smith about $3 a ton to mine, and it does not cost him more than $7 a ton delivered in Montreal at the outside. We cannot handle farmers' phosphate because they will not mine it carefully. To ship to

Working mines in Frontenac.

Occurence of phosphates.

Cost of production.

Europe at the present time, it has to go 80 per cent. to make it a profitable business. I have not visited the mines in any other phosphate district, but I know that as far as quality is concerned the phosphate from this district is equal to any. I think phosphate occurs in pockets everywhere, as it does here. We can readily trace the belts or ridges in which it occurs; if we follow one we will find outcroppings. Their general course is north-east and south-west. The red phosphate we find with red granite and the green phosphate is found with grey granite. We have found some very rich white phosphate, and have shipped 200 tons of it. I do not think the color has anything to do with the quality, though a great many people prefer green. I have had it almost black, and very rich. Sometimes we find a vein carrying iron pyrites, but the pyrites will generally run out. I have been in the business twelve years, and up to four years ago we used to average 4,000 tons a year. Since then the market has been poor. The price now at Kingston is $14; twelve years ago it was $8 to $9, but I have paid as high as $18 and $19. The old country is our best market at present. Phosphate goes duty free to the States, but the Carolina phosphate though only 54 per cent. is easy to manufacture and takes less acid; it sells I think for about $11 a ton. There is no fear that the demand will fall off. Superphosphate is not used by the Canadian farmers. We have given out some in the raw state, but the result that way is very slow. I know of a case however where a farmer put it very thick on a few acres of wheat and had a double crop afterwards.

Colors of phosphate.

Market for phosphate

Raw phosphate as a fertiliser.

N. D. Moore—I am interested in some of the mica and phosphate properties in the Sydenham district, in the township of Loughborough. We have given leases on several of the properties which are being worked, but we are not working any of the properties ourselves. They were formerly known as the Smith and Lacey and Purdy properties. There are about 1,050 acres in the tract. On one of the tracts which we have leased, and which contains about 50 acres, the lessee claims to have 149 openings and probably 40 or 50 veins, and he is cross-cutting these veins at a depth of from 75 to 100 feet below the surface. I am decidedly of the opinion that phosphate occurs in veins, the same as iron ore, and that it is of irruptive origin. While I am of the opinion that the veins are continuous, it will require considerable testing in this locality to prove whether I am correct or not. The surface showings of phosphate are from six inches to six feet wide. So far they have in almost every instance run out in going down, but that is what I would expect, as I have seen the same thing occur on every one of the iron ranges that I have operated. For instance, in the old Marquette range of Michigan the appearance of the surface workings of the different mines is more like the diggings in the phosphate region here than anything else I know of. In almost every instance the surface showings ran out entirely and sinking had to be done, sometimes to a great depth before the vein was encountered again. I fully believe, therefore, that at greater depth in our phosphate country the veins will not only get stronger, but that the quality of the phosphate will very materially improve. We have a company organised, composed of American and Canadian capitalists. The amount of the capital stock is $50,000, which is all subscribed and paid for. A little more than half is held by Canadians. The intention is to develop phosphate and other minerals. We intend to work more especially on the phosphate at present. We are not hauling phosphate yet, and do not intend to do so until we get good sleighing. We are eight miles from the railway, and expect to sell our phosphate in Montreal. We have offers for all the phosphate we can mine for three years. The demand in the States for Canadian phosphate is increasing, while the Carolina mines are getting poorer. We are drifting into two hills to strike and cross-cut the veins at a depth of 75 or 100 feet from the surface. Sometimes the pyroxene takes the place of mica in the phosphate veins. I understand that pyroxene is considered a good indication of phosphate.

Phosphate properties in the Sydenham district.

A working company organised

James Foxton—I reside in Sydenham and am engaged in phosphate mining. My property is situated in Loughborough, being composed of lot 13 in the 10th concession, 100 acres. When I acquired the property twenty-five years ago no phosphate had been discovered upon it. I made the first discovery and opening about eleven years ago. We have altogether about four hundred shows opened up. In many places we find the phosphate in veins, but we have not followed them down more than eight or ten feet, except one that we are working now and two others that are down about twenty feet. I think the vein we are on extends across the lot. There are other veins parallel to it, the general course being about north-east and south-west; that is the general course of the country rock. Veins extend across the whole breadth of the lot; in some places they are not more than four or five feet apart, and in other places fifty feet. I do not consider that we

The Foxton mine in Loughborough.

Extent of the work.

have thoroughly explored the property, nor do I think that we have discovered all the veins that are upon it. We began operations on the deep pit about five years ago, and its present depth is 115 feet; the vein is there about fifteen feet wide. I think I have taken out altogether about 4,000 long tons; during the present summer I have taken out about 416 tons, averaging about 82 per cent. Last year I got out about 300 tons that would average about the same per cent. It then realised $13 delivered at Kingston. This year for the 68 tons I have in Kingston and what I have here I have been offered $14, but I think I will get $15. We have good facilities for shipping. In summer we haul it to Eel lake, put it on scows and take it five miles of the distance to Kingston that way; after being taken off the scows it has to be hauled the rest of the way. By rail they charge $10 a car from Harrowsmith to Kingston. That is equal to a dollar a ton, and it would take 75 cents a ton to put it on the car from the mine. My team hauls about 4,600 or 4,800 lb., and in winter they often haul 6,000 lbs. In this way we can deliver the phosphate at Kingston for $1.25 per ton. Last summer we employed six or eight lads; we don't require men for the work. We drill by steam, and there are two men to attend to that. We have a boiler, engine, steam hoist and steam drill. In summer time I paid the men $13 and board, and the boys $8 and $9. They will not clean the phosphate properly if they work by contract. I have only one helper with the drill; my son runs it. We do not timber our shaft, as I do not think it is needed; it is a perfectly solid rock, and there are no seams in it. The drifts are at the lowest level of the shaft. There is not an ounce of mica in a hundred tons of phosphate with us. It costs about $4 a ton to raise the phosphate if 15 or 20 feet deep, and it does not make any difference down to 150 feet. Working at 20 or 30 feet with a windlass took two men to attend to the windlass, while now at a depth of 115 feet we raise the bucket by steam and it costs much less. A quarter of a cord of wood gives us all the steam we want for a day, and I get the wood at $1.25 a cord. I can deliver the phosphate for $4 a ton at Kingston from the deep vein. We raise about five tons a day. We have done some drifting; south-west we have gone about 45 feet, and north-east about the same, but we have not stoped out any yet. My phosphate is principally green, but some of the showings are red. In the deep shaft it is all one color. In the other showings there is some of both colors. I do not know of any cross veins. I know this section pretty well. There is an immense range of phosphate rocks about fifteen miles long and about three miles wide; it runs about east and west. I think Boyd Smith's location is about the limit to the west. The range extends to lake Opinicon, and that must be twenty miles. There is phosphate in Bedford, but the country has not been prospected except here and there. It is in Loughborough, Storrington, Oso, Hinchinbrooke, North Burgess and North Crosby. It would be found all through the back country if explored. In quality we can equal that from the province of Quebec. There is a good deal taken out by farmers who do not understand anything about mining; they leave a great deal of dirt in it, and that has given Ontario phosphate a bad name.

Shipping facilities.

Labor and wages.

Color of the phosphate.

Extent of the phosphate area.

The Blessington mines.

Boyd Smith—I reside at Washington, D.C., and am interested in the phosphate mines at Eagle lake and St. George lake, known as the Blessington mines. The Eagle lake property consists of lots 29 and 30 in the 1st concession of Hinchinbrooke, and lots 29 and 30 in the 1st of Bedford. The St. George lake property consists of lot 6 in the 1st of Oso. The area of the Eagle lake property is between 800 and 1,000 acres, and of the St. George lake property about 200 acres. I began operations on the St. George lake property about four years age, and on the Eagle lake property about two years ago. From Eagle lake I have taken out about 3,200 tons, and from the St. George property I have shipped about 1,000 tons. The output from the Eagle lake property this year has been 1,200 tons. I have worked the St. George lake property this year about three months, and have taken out about 300 tons. What I have sold has averaged me $15 a ton. The average of my phosphate has been 83, 85 and 86 per cent. My shipments to England last year averaged 84 per cent. My shipments to the United States went over that. This year and last year together I shipped to England 2,200 tons; the balance went to the States. My best market is in the States. That is partly owing to my friends being there, but I think that eventually that country will be the market for Kingston phosphates. The freight to Philadelphia is less than to England, while the price there is about the same. The market in the States is growing all the time. Where they took 200 tons the first year they took 500 the second, and are willing to take 1,000 this year. The number of men we employ varies. Last summer we had about 80. Now we are working 37 on the St. George lake pro-

Quantity of phosphate mined.

Markets.

Labor and wages.

perty and about 12 at Eagle lake. In winter we can only work in the deep pits. We pay boys 75 cents, muckers $1, and other men from $1.10 to $1,50, except the superintendent, who gets $2 a day. The phosphate occurs in half a dozen lodes, running north-east and south-west through the whole of these four lots, a distance of a mile and a half. The width across the belt where the lodes occur is about 300 yards. The lodes are from six inches to six feet, and are irregular, running in pockets and chimneys. We have made about twenty openings at Eagle lake, the greatest depth being about 140 feet; the others are from 25 to 60 feet. At the St. George lake property the phosphate occurs like seams of coal between granite and limestone, and is worked like a quarry. The dip is very uniform, at 40°. On the Eagle lake property there is a good deal of magnetic iron. Occurrence of the phosphate.

James Bell—I am interested in a phosphate property in the township of Storrington. I have a mining lease from the Canada company of 82 acres, acquired four years ago this fall. The first mining on it was done ten or twelve years ago by a man named Teeple. I put on a steam engine and a steam drill, and cut the shaft over again to admit of a tramway being built. I have sunk to a depth of 150 feet at an angle of 45°. The hanging wall is syenite. The vein is well defined all the way, it pinched in several places, the narrowest being about a foot and a half, but now it is about six to eight feet wide, which is the widest it has been. We had it continuously all the way down 150 feet. At a depth of 150 feet we drifted east about 75 feet, and the widest part is at the farthest end of the drift. The rock was much softer and easier to drill down below; there was no pyrites. We worked about seven months last year and the year previous, and took out about 400 tons. We commenced work this season, but our buildings were burned down in the latter part of June. The general character of the phosphate on the west side of the descent was green mixed with red, while on the east side it was nearly all red. Some of our phosphate is 85 per cent. Our analyses of it would average 80 per cent. It has to be cobbed, and that is where the expense comes in, as there is some black hornblende with it. I shipped to Hamburg and London and got about 25 cents a unit. That would give about $20, and is better than selling in Montreal. I never would ship to consignees, as they have so many charges that it would be almost as well to sell at home. I sold 29 tons in the American market, and the sale was satisfactory to us. My idea was to grind the phosphate and sell it in bags. I can get $20 a ton for ground phosphate averaging 80 per cent. at the mill. I had about 14 or 15 men employed when working; they were all miners, and about six or seven were in the pit. I paid from $1.10 to $1.25 per day to miners, but to the engineer and fireman I paid $1.50. We will have the works in operation soon again. Working a deep mine in Storrington. Quality of phosphate. Markets. Labor and wages.

W. H. L. Gordon—We know of apatite in three townships in Haliburton. There is a very fine showing in Dysart. We had some of it analysed here and in the old country. It proved to be very good; the old country analysis was the higher of the two. I cannot say whether it is a vein or a bed. In the township of Dudley it is in the side of a hill, and appears to be a vein. I have traced it myself quite a distance. It occurs in lot 3 or 4 of the 4th concession. On an island in Long lake, exactly east of that deposit, we found fine specimens of phosphate; I think it continues right along. The Dysart deposit is on a hill within 400 yards of the railway. Phosphate in Haliburton.

J. Campbell—I found some phosphate on lot 6 in the 10th concession of Monmouth, but I do not know the extent of it. Monmouth.

James Bell—I am registrar of the south riding of Lanark. I have done a little prospecting for phosphate and mica. Lots 7 and 8 in the 7th concession of Burgess were opened by me ten years ago, but nothing more than small pits were put down. On the adjoining lot a shaft has been sunk to a depth of sixty or eighty feet, and a great quantity of phosphate has been taken out. A gentleman from London, England, worked it for a couple of years. There is any quantity of it there. My impression is that the country is rich in both phosphate and mica, but I think the best lots are held for purposes of speculation. The bulk of the phosphate has been taken out by the farmers under contract, but their work has been only rooting on the surface. The English companies went to the other extreme, sinking shafts, getting steam engines and putting up buildings before they knew whether there was anything to justify the outlay or not. Phosphate in Burgess. Methods of working the deposits.

W. J. Morris—Apatite occurs in North Burgess in gash veins and deposits, one cannot call them real beds. There is no regular run to the rocks sufficient to

follow for any given distance. That is the edge of the disturbed belt; the veins themselves are often dislocated. The Matheson deposit on lot 2, in the 8th of Burgess was the first opened in Canada. Work was commenced on that lot about 1855 or 1856, and has been continued more or less to the present time. Apatite is also found on the north shore of Bob's lake in the township of Bedford; there is a true vein traced about 300 feet, opened nearly 200 feet, and worked to a depth of 80 feet. The walls are principally pyroxene. The vein when I saw it was six feet wide and a mass of crystals for eight feet deep; it widened out to 15 and 16 feet. At times arsenical iron pyrites gave trouble. The finest crystals in the world were got there; I got one that weighed 1,000 lb. I have seen hundreds of crystals weighing from 50 to 100 lb. In loading cars we have had to break every crystal with the hammer for fear they would be stolen as specimens. These crystals were found in the first six feet of depth. On the walls there was a lining of a kind of soapstone. We were not bothered with calcspar in the vein.

Occurrence of apatite in North Burgess.

The oldest mine in Canada.

Crystal apatite in Bedford.

William Davies—I reside in Perth, and I am a mining superintendent. I have been in this vicinity about eighteen years, and have been interested in mining development all that time. I have some interest in property from twenty to thirty miles from Perth, but have been chiefly interested in phosphate mining in this district. I have not mined any phosphate for about a year before that I managed the Anglo-Canadian Phosphate Co.'s mine for about eight or nine years. In my opinion the phosphate occurs in pockets running lengthwise, and the same way down. If we get it on the surface and it plays out at both ends we will get it again, but it may be in large or small quantities. The walls are generally granite or pyroxene, and there is a good deal of mica mixed with it. The mica is generally in the pyroxene, which forms one or both walls; sometimes you get the pyroxene without it. Speaking generally, granite forms one wall and pyroxene the other. There is a good deal of crystalline limestone, and it is often associated with the phosphate. Sometimes we find that the phosphate and the limestone are mixed up in the vein very largely. We don't find it forming a wall, but chiefly as part of the vein matter. There are some large bands of crystalline limestone in Burgess, some of which are rich in phosphate, but most of them are not. There are deposits at Otty lake that can be traced for half a mile. The contents of some are pure phosphate, but there is generally a slight mixture of mica, and the phosphate is generally associated with pyroxene. Sometimes it is full of small lumps of black-jack; sometimes, but very seldom, we get tourmaline; and sometimes pyroxene is mixed with it. Limestone is, I think, the most common mixture. Occasionally we find iron pyrites, but not often. The largest deposit of phosphate I have seen in this district is a vein with two perfect walls; it is a mixture of phosphate, pyroxene, mica and limestone. The walls are 25 feet apart. It is on the east half of lot 13, in the 6th concession of Burgess. It belongs to Mr. McMartin and is not being worked now. There are two pits on it, one 50 feet deep and the other 40 or 50 feet. On 10 in the 6th of Burgess there is a shaft 130 feet deep, and I am told there is about 2½ feet of phosphate still in the bottom. The vein in one place was five feet wide, but it pinched. The reason work stopped was because all the machinery was burned. I do not know much about the Ottawa district, but I have seen specimens from there, and I have seen phosphate here equal to anything they get there. The formation in the Ottawa district is altogether different from ours. It seems to occur in large bunches down there; here they are smaller and seem very like veins. There are more of them, more regular and smaller. I do not know much about the rock at the Quebec mines, but it seems to me that there was a good deal of mica and pyroxene; it is pretty much all pyroxene down there. We have more limestone and mica here. The Quebec phosphate is, I think, nearly all green, while most of the phosphate here is a reddish green; it is mostly colored a little. There is some here as hard as granite. The purity of our phosphate depends upon the mining. By proper mining we can get it 80 per cent., and higher if we wish. Our people have been more careless, and the Ottawa district has got a better name. I think the contract system is to blame. I think the prospects as to the quantity here are as good as they ever were; people are making new discoveries all the time. Within the last two or three years prices have not been good. Miners are satisfied to get $12 a ton for 80 per cent. on the Rideau canal or at Perth. It would cost $7 to get it up, and then the carting would cost according to the length of the haul. Some of the deposits require no cobbing at all; they will go 80 per cent. without touching them. In the ore we ship, seconds would run about 60 per cent.; they are about

Occurence of phosphate.

A large vein.

The Ottawa district phosphate.

Color and quality.

one-third of the whole. I do not know whether it could be profitably mined to a great depth. It is very uncertain, and one cannot make a calculation about going down; sometimes large surface showings play out in two feet. We never use a diamond drill, and I don't think it would be safe to depend on; it might result in condemning a place that did not deserve it. Sometimes the veins dip considerably; sometimes they run in and out; there is no regular dip about them; there are no two of them alike. Sometimes two veins join below, and then we look for a larger bunch.

Deep mining and proving.

George McMartin—I have been interested in mineral development in the Perth district for twenty years, with the exception of three years when I was away. I have worked both phosphate and mica. The phosphate properties are in the 5th and 6th concessions of North Burgess, lots 4, 5, 6 and 7 in the 5th, also 8, 9 and 10 in the 5th, and 11 and the north-east of 13 in the 6th; those are the principal ones. The phosphate occurs generally in veins in that part of the country. In the 5th concession the veins are well defined; they run north-east and south-west, and have water frontage on Otty lake. Some dip, but as a rule they are flat. The rock is a hard grey granite and the walls are perfect as if chiselled. The vein matter is pyroxene and mica, but occasionally we run into crystallised calcspar. The veins are from eight inches to three feet wide. There has not been more development owing to the want of capital. The work is let out by contract; therefore quantity is the object with the men, and they throw in dirt. I am speaking of one lot on the Rideau; there are twenty-two veins on the bank of the Rideau there, but only two of them are three feet wide. Some of the veins small on the surface widen, while other times those that are wide on the surface pinch out. It would be difficult to say what a vein will do farther than one sees it. One of the reasons why they have not been worked is, I think, because they are in veins and there is so much dead ground they could not be worked to any depth. If the vein kept perfectly pure and three feet wide it could be made to pay, but not at the present price. To meet all markets it would take a six-foot vein for profitable working. Our phosphates here are very pure, but at the present price these thin veins could not be made to pay. We have many wide veins on other lots, generally in calcspar. They are from 10 to 25 feet wide, but are not pure phosphate crystals; there is a good deal of calcspar. These have not been followed to any depth. We went down about fifty feet on two of the narrow veins; the phosphate gave out at a depth of about twenty-five feet, but we struck it again before we got down to fifty feet. On the north-east half lot 13 in the 6th concession the walls are perfect and about 25 feet apart. The intervening space is filled up with calcspar, phosphate and pyroxene. Such veins could be worked at $7 a ton. Taking the vein as it goes, without cleaning it at all, it would go about 50 per cent. phosphate; in many places it would yield 80 per cent., but 50 per cent. is about the average. The present price would not pay to do deep mining, on account of the narrowness of the deposits. Then again we can't sell it all here; the quantity taken out is not sufficient to induce the buyers to come. A man near me has twenty tons, but he cannot sell it; if he had a cargo perhaps he could dispose of it, but now he has to hold it.

Phosphate properties in North Burgess.

Occurrence of the phosphate on Otty lake.

Narrow veins not profitable.

Robert C. Adams—My residence is Montreal, and I am managing director of the Anglo-Canadian Phosphate company, of Liverpool, England. The company was organised two years ago last summer; the chairman is Sir John Morris of London, and the secretary is Mr. Brainerd Radcliffe of Liverpool. The subscribed capital is about $140,000, and is all paid up. I have been interested in apatite mining in this country about eleven years, largely in the townships of North Burgess and Bedford, and also in Ottawa county, Quebec. Our company has acquired all the properties I originally owned, and some others close to them. Those in North Burgess are in the 5th to the 9th concessions, and comprise 3,150 acres. The Bedford property consists of a mining lease of some 600 acres, near Bob's lake. Mining commenced as soon as the company was organised; they continued the work I had been doing and enlarged it. We attempted deep work, with compressed air, but it was not successful. The seams were not sufficiently continuous to warrant that kind of work; they would get small at times, but they did not give out. We found the work was more expensive by machinery, and we therefore have gone back to the old method. We are down 100 feet on lot 5, in the 8th of North Burgess, upon a vein across the strata, and there is another shaft about 80 feet on a vein at right angles to the first. As we went down the vein that ran across the strata we noticed a considerable difference in the phosphate. It turned largely into sugar phosphate, and our analyses were much

Anglo-Canadian Phosphate company.

Properties of the company.

Mining operations.

Sinking upon two veins to depths of 80 and 100 feet.

higher, so much so as to surprise us. The phosphate that we usually estimated at 80 per cent. analysed 86 per cent.; while what I laid aside for 75 per cent. went 81 per cent. At a depth of 100 feet it improved in quality, and I have no reason to suppose it would pinch out. We did some drifting, and found the same characteristics as in the shaft. We opened on the length of the vein in the shaft, and have worked at least 100 feet. There are perhaps 200 or 300 little pits on this property in North Burgess. My impression is unfavorable to the use of machinery, owing to the fact that the gangue rock in that district is apt to be barren, while in the Quebec district the whole rock will be honeycombed with phosphate. In this locality it is more confined to veins. The average width of the veins, I think, is between two and three feet, the widest being about seven feet. Veins seven feet wide were found last year; they pinched out, but I have no doubt they would come in again. I believe a very large quantity of apatite is to be found in this region. The great difficulty is the irregularity of the deposits. Last year we took out from 800 to 1,000 tons, and the largest year's work upon that property has been about 1,500 tons. This year, so far, we have taken out between 500 and 600 tons. We employ from 15 to 30 men. I think the contract system is the better, and we have now gone back to it. It is much better in many respects, owing to the deposits being so scattered that it is difficult to superintend the men. The objection to the contract system is that the quality is apt to be less good, and the work requires careful watching. When working by the day we paid $1.25, and by the contract $6 a ton. It varies, of course, with the depth. For surface work we were paying $4.50 a ton; at a depth of 70 or 80 feet I paid about $5.50. It is difficult to get men to work at a depth, and when they get to about 30 feet they seek for a new pit. When they follow a vein they just gouge the mineral out, and when we come to work it again we have to do some dead work to get it fit for working. Our market is in England and Germany. Germany is the best market for the very high qualities, but the ordinary grades find the best sale in England. My average from the North Burgess mines has been about 79 per cent.—from 74 to 84 per cent. One year by contract it averaged 79 per cent.; that is a high average for contract. We make 75 per cent. the minimum. The price at present at Montreal is about $12 a ton for 75 per cent. phosphate. There has been a great decline. Formerly we got 1s. 3d. a unit for 70 per cent., but the price now is 8½d.; 84 per cent. phosphates would be worth $18 per ton in Montreal now. Some years ago it was worth $23 or $24 a ton. I think superphosphate can be manufactured here. The only difference is as to the supply of sulphuric acid, but I think there is so much iron pyrites in the country that a place could be found for treating it. I think that in accordance with the experience of other countries the demand for superphosphates is bound to increase. They are largely used in the States. The trade is opening up in that country and there is a great demand for our product, but principally for the lower grades. I think the reason they take the lower grades is because they have been in the habit of using the Carolina phosphate, which contains only about 54 per cent., and they have not had any experience with high grade phosphates. I do not see why the manufacturing of superphosphates should not be profitably carried on here. I have experimented myself in my garden at Montreal with raw phosphate. The effect on some of the roots and plants was wonderful the first year, and I think it affected the crop the following year. The matter of the American market, however, is a very important one, as also is the encouragement of the use of phosphate at home; the good effects arising from its use in other countries show that it is of great value to farmers. The supply of Carolina phosphates is plentiful, and this year they are taking out more than ever, but the output of half a million tons yearly must in time exhaust the supplies. I don't think the quantity in this district is as great as in the province of Quebec; I am speaking of North Burgess. It is not found in as large single deposits as in the few highly successful mines in Quebec; but with those exceptions I would say it is in as good quantities. It is not on the average quite so high in quality as the phosphate from the Lievre district. It is all very similar throughout the whole district from North Elmsley through into the townships of Sydenham and Loughborough. The most productive work has been done in the section near Otty lake, some 15,000 tons having been produced from those lots alone. It also occurs in Bedford, Hichinbrooke, Storrington and North Crosby. I am now working also at Bob's lake, in the township of Bedford, Frontenac county. The deposits there are remarkable in character, and consist largely of crystals occurring in soft rock, so that a great deal can be taken out with the pick and shovel without the use of explosives. I am working there on contract, and for the last two months the men

Irregularity of the deposits.

Daywork and piecework.

Market for the phosphate.

Manufacture of superphosphate.

The American market.

The supply.

Area of the phosphate district.

have been taking out double the usual quantity per man, and they are making as much as $2.50 a day at the present time. The percentage is very high. It is all over 80 per cent., and a great deal contains 92 per cent., being crystals, but the average would be what I have stated. The veins are small and numerous, varying in width from one to three feet ; they mostly run north-west and south-east—that is across the stratification. As a rule I think they run parallel. A great number of the veins are being opened now. The country to the north has been explored for apatite lately and I have heard of some openings but none have been worked continuously. I do not see why they should not be as good there as elsewhere. I think the country has been pretty well run over by prospectors, but a great deal of it is thick bush, and it is very difficult to determine its character. The characteristics are about the same, I think, as in North Burgess. We have less cobbing work than they have in Quebec, but on the other hand less productive rock, the phosphate being in distinct seams. The country rock at Bob's lake is pyroxene. At North Burgess there appears to be a mixture of pyroxene, limestone and quartz rocks. The quartz occurs in large beds and veins. Some of it is said to be auriferous. We have had analyses as high as $22 to the ton from some quartz from North Burgess. I have been assaying a good many specimens myself, and I found gold, but none in appreciable quantities. The rock is principally pyroxene, but there is a large quantity of dark amber-colored mica which has little commercial value. The reason machinery did not succeed was because the seams were too small, and we had to cut a larger space so as to be able to work the drills. On account of the amount of work it is not as cheap to use machinery in small veins. I refer to compressors and drills ; of course we use hoisting machinery. We have done very little drifting ; a great deal of time has been wasted hoisting water. If the mining were done by hand and the hoisting and pumping by steam they could succeed better. We generally employ in one pit a gang of four or five men. One-fifth of a ton a man is generally considered about the average work. Five men will take out about a ton a day where they are at all successful. I should say that the deposits never run out ; they pinch for a space and then come in again. I think they are persistent, but vary in size. The only reason for not going deeper is the cost ; it is more economical to go to another place. When the price was high a great deal of the phosphate was taken out by farmers themselves, and they still take out a little, but I do'nt think they mine intelligently.

The Bob's lake mines.

Exploring for phosphate.

Auriferous quartz.

Economy in working the mines.

B. T. A. Bell—I am a journalist and editor of the Mining Review. I have taken an interest in mining for several years, and have been directly connected with it for two years. During that time there has been a material increase in the amount of capital invested in our mines, a larger number of men have been employed, and I think the output of ore has steadily increased. I am referring now to phosphate mining, which is the principal mining interest of this vicinity. I have not had an opportunity of visiting mines along the Kingston and Pembroke railway yet, but have some fine specimens of their ore and know what is going on at the mines. I am particularly impressed with Boyd Smith's mine, the specimens from which are quite equal to any from the Quebec side. From Sydenham I have specimens that I think would go 90 per cent. I do not know of any reason why phosphate from the Kingston district should not be equal in quality to that from Quebec. In the Perth district there are large surface showings, but it is not possible to say yet to what extent the veins continue. In the Ottawa valley it has been proved that the deeper the veins are followed the better and purer the mineral becomes. At the Foxton mine, near Sydenham, at a depth of 115 feet the vein is from 8 to 15 feet wide and improves as it goes down. Last year it is estimated 23,690 tons of phosphate were mined and shipped from Canada—from the Ottawa district 18,955 tons, and 4,735 tons from the Ontario district. The amount from the Ottawa district I got from the way-bills. The exports are however less than last year on account of difficulties in sending down the mineral on the Lievre river and the unusually high ocean freights. Large quantities are held over till next season. There is some talk of establishing fertiliser works here. The great difficulty has been to procure sulphuric acid ; now, however, tests have been made at Capelton by G. H. Nicolls & Co., and it is believed the experiments have been successful. The demand for our phosphate in the United States is increasing. Taking the figures as given by the American consul for this district, I find that in 1884 our sales to that country were *nil* ; in 1885, $775 ; in 1886, $1,106 ; in 1887, $5,467 ; in 1888, $12,000. That was all second class ground phosphate. I believe if the figures were obtained from the Perth and Kingston districts these figures would be very much increased. Those I have given are for the Ottawa district alone. The

Impressions of Ontario mines.

Exports of phosphate.

Manufacture of fertilisers.

Exports to the United States.

freights from Kingston are of course very much less than from here, and very much less than phosphate can be shipped from Carolina to Buffalo, Chicago and other lake points. Our phosphates are about 30 per cent. higher than the Carolina phosphate, too.

William A. Allan—I have been interested in mining matters for about thirteen years, mainly in connection with phosphate and mica. During that time the only phosphate property I have developed in Ontario was the Pixley mine in the township of Burgess, but in Quebec I have developed several mines. In the township of Templeton, Que., phosphate occurs in a coarse crystalline limestone and pyroxene. I don't think the phosphate in a limestone formation goes to a great depth, at least that is my experience. There have, however, been exceptions to that rule ; at the Blackburn deposit they have gone down 80 or 90 feet, and there is a large showing, but that is exceptional. We look for phosphate in the pyroxene masses, as it is the most common associate of the apatite deposits. In the townships of Buckingham and Portland the phosphate occurs altogether in the pyroxene rock, with occasionally hornblende, calcspar, scapolite and little dykes of granite. The dyke is not more than from three to six inches wide, and on both sides of it we find phosphate. In Wakefield a great deal of the phosphate is red ; in Templeton there is red and green ; in other places it is mostly green. I have not seen any variation in color caused by veins running in different directions. Some of the phosphate veins are very pure ; in others there is a considerable quantity of black mica. Pyroxene veins occur in interlaminated bedded masses, and in what is called bastard granite ; it is not as hard as granite, it is a rock one can cut with a knife. Phosphate-bearing pyroxene occurs principally in bands, which are sometimes dioritic. As a rule the bands are seldom more than twenty or thirty feet wide, except in places. The pyroxene is of different colors ; in some instances it is very dark, at other times it is of a much lighter shade, and in somé instances it very much resembles the apatite itself. A Mr. Garrett some years ago mined more than 600 tons of pyroxene, thinking it was apatite. I have not examined the phosphate district of Ontario to any extent. I operated in the Perth district, in Loughborough and Burgess, for a couple of years, but found I could not work with a profit as the deposits were too shallow and small ; they were principally associated with limestone and did not hold out. I bought the Pixley property in that district, and took out about 200 tons, and then sold it. One of my best men made for me a report of a property in the Sharbot lake district, and it was not favorable. I have had men exploring all through the Kingston and Perth districts, and they never discovered anything that I would consider equal to the deposits in the Buckingham district ; it is apt to be more pockety there. The Ontario phosphates do not often go over 80 per cent., and the average would be about 76 per cent.; they range from 60 to 80 per cent. If shipped clean and carefully separated it would go from 76 to 80 per cent., and some might go as high as 82 and 85 per cent. The highest shipment from the Little Rapids mine was 174 tons, 85.60 per cent.; that was the highest from Canada, and was equal to $19.30 a ton in Montreal at last season's price. A shipment of 172 tons went 84.84 per cent.; that was equal to $18.80 in Montreal. The best market for high grade ore is Hamburg, but we have to guarantee 80 per cent. We shipped some of the first quality to London and Liverpool, and I think the net results were about the same, as we get much lower freight rates to Liverpool than to Hamburg. The output from the mines is increasing every year a little, but not very much. At Buckingham they grind some of the 60 per cent. phosphate, and it is shipped in bags and sold in Chicago. It is a mere experiment, and I don't know what they get for it. The freight from Montreal to Liverpool averages from 2s. 6d. to 10s., and to Hamburg 12s. 6d. to 15s. The commission charges are not very heavy, from 60 to 75 cents a ton will cover all charges. The commission for selling it in London is 2½ per cent., the weighing costs 1s. a ton, examining 10s. 6d. a shipment, analysis (of which the seller pays half and the buyer half) from £2 to £3. There are some other charges, but taken roughly after it leaves Montreal 2s. 6d. a ton will pay all other expenses above freight. I think most of the ore is shipped at an average freight of about 5s. or 6s. per ton. The advance in ocean freight rates generally occurs late in the season, when grain begins to move. Taking all charges, it amounts to about $4 from the mine, and that leaves a fair profit for the miner. In Buckingham wages are about the same as in Ontario. Ordinary miners get from $20 to $25 a month and board. We give good steam drillers $1.50 a day and board ; good ordinary hand drillers $1.10 and board ; ordinary miners and laborers, $18, $20 and $21 a month and board. Machinery is very extensively used. At

Occurrence of apatite in Quebec.

The Perth district.

The Sharbot lake district.

Market prices and markets.

Freight and other charges.

Wages in Buckingham.

Little Rapids the vein will average from the top to the bottom five to six feet. It pinches and widens again, but it is continuous throughout. The greatest depth we have reached is 210 feet. At the North Star mine they have sunk to a depth of 620 feet, but I cannot tell you the width of the vein there. It has been traced on the surface for half or three-quarters of a mile, and outcroppings appear here and there.

Workings at Quebec mines.

Robert J. Brodie—The Standard Fertiliser and Chemical company of which I am president was organised a little over three years ago. The capital is $50,000 and half is paid up; it is all Canadian capital. I started the work originally myself about nine years ago. The most expensive part of our plant is the sulphuric acid chambers. We have machinery for grinding and mixing; we have drying kilns, sifting machinery and vats—all the machinery that is requisite. We make our own sulphuric acid from brimstone, most of which comes from Sicily, but we occasionally get some from Japan. It used to come over from Japan as ballast, but of late the Canadian Pacific railway has taken a good deal of the trade of that country and very little comes that way now. It is as good as pyrites, and as far as I can make out it is more economical. The brimstone costs us about one cent per pound at the works, and perhaps a little more sometimes; we buy by the long ton and pay $23 a ton. To manufacture the superphosphate we grind the apatite very fine, from 80 to 120 mesh. It is ground with buhrrstones and then we air-float it. It is let fall past the suction chamber where it is drawn in, the coarse stuff falling down and being put through the mill again. We can regulate the power of the suction and so get any required fineness. After it is ground we measure the charge for the mixer; we measure also the exact quantity of acid and run the two in the mixer. After it is mixed we run it into an air tight bin which is supplied with a wooden funnel to suck up the hydrofluoric acid gas. This gas is very dangerous, and the want of a funnel caused loss of life in Chicago recently. When it comes into the bin it is about the consistency of porridge, but inside of twenty-four hours it is dry and hard. It is broken up then and is ready for the market. That makes the superphosphate. To make different kinds of fertilisers we mix it with ammonia, potash, etc. We make five grades, the Fruit-tree fertiliser, the Peach-tree fertiliser, No. 1, Standard, and Special, besides which we sell a little of the raw phosphate. The quantity we manufacture varies; last year we made about 300 tons; before that it was a little less. The demand is increasing, and I have no doubt we could sell a thousand tons if we could make it. We generally have more than the farmers want in the fall, but this year we had not one-tenth of what they wanted. I think this year we will make about 500 tons. We buy our stock and have to pay cash for it. Farmers are recognising the merits of it, and last year we sold it to old customers without having to advertise at all; they sent in their orders almost without solicitation. We sell quite a lot to fruit growers in the Niagara district. We sell quite a lot to market gardeners, too. The principal district where farmers take it is in the Eastern Townships, Quebec. The reason of that is because we worked it up there more than anywhere else. We have never tried to sell it amongst the farmers in the western part of Ontario at all; we have never had enough made. Experiments have been made with the raw phosphate; I supplied quite a lot of the finest ground to farmers, but they said they could not see any difference on account of using it. They did not actually weigh the grain, but they could not see any difference; while using the superphosphates they could see the difference. As far as I know no good has resulted from the use of the ground apatite. I have never yet sold a bag of raw a second time to the same man. We went to a good deal of expense to get farmers to try it; we sent out fully $100 worth of the raw ground. The only condition was that they should report to us the result. We got them to sign an agreement that they would let us know the result, but only a few did do so, and the result so far as ascertained was as I have stated. The reason more fertilisers have not been used is on account of the agricultural depression. If times improved more of our fertilisers would be used, judging from the increase in the demand this fall owing to the higher price of wheat. Our prices are, Superphosphate $26 a ton, No. 1 $32, Standard $35, Special $40, Fruit-tree $40. About seven-eighths of our whole output is Special and Standard; it sells for $35 and $40 and gives the best results. We sell very little superphosphate alone; we sold a couple of car loads for sugar beets. Our output last year in value was of fertilisers about $10,000 and of acid-phosphate $7,000, making a total of $17,000. We make acid phosphate from the purest green phosphate. We select it very carefully by hand and make it into superphosphate; then we leach off the soluble acid phosphate from the superphosphate which gives the liquid acid phosphate. To make the dry acid we concentrate it in enamel

Smith's Falls superphosphate works.

Process of manufacture.

An increasing demand for fertilisers.

Raw apatite

Acid phosphate.

kettles. When it is evaporated down to a syrupy or pasty mass we mix it with starch ; then we dry and grind it ; that is the whole process. It is used as a substitute for cream of tartar. We make about 250 lb. a day. We will average that throughout this year. Our market is in Canada. The acid phosphate that is supplied at a dollar a bottle could be supplied with a large profit at 7 cents a bottle. We could sell acid phosphate by the pound at 7 cents making it with terra alba, but the best grade should be 10 or 12 cents ; our best grade is 12 cents. I am a graduate of the Magill College of Science and do my own analysing. Every January we send samples to the chief analysist of the Internal Revenue at Ottawa, and you will find that our produce has been up to sample in every instance. We make sulphate of lime and sulphate of soda ; it is used in the glass works at Montreal. We do not make nitric acid for sale ; we use it for making sulphuric acid. Farmers say that 250 or 300 lb. of our fertilisers will have the same effect as 20 or 25 double loads of well rotted manure, and they claim that the effects are seen for two or three years. We recommend 350 or 400 lb. to the acre, and market gardeners put on from 800 to 1.000 lb. For spring crops it is better to put it on in the spring. It is better suited for clay and loam soils ; in some lime soils it does very well, but then it is quite possible that it is the potash and ammonia that are doing the good. When mixed with the sulphuric acid the phosphate gives up two of lime but won't give up the third, and it is claimed by some that when it is put on lime soil it will take up two of lime out of the soil and go back into the original form. The ammonia in a ton of Special costs us $11. We import the potash from Germany ; we also import some ammonia and get some here. The apatite we get sometimes between here and Kingston, sometimes from lake Pelican in Burgess, and sometimes from Buckingham. The apatite of this region is about the same as that from Buckingham. I got some small lots from this section that I thought purer than any I got below ; it seemed to be very dense. It would not pay us to make acid from pure pyrites at $10 a ton. It would require more chamber space, and the chamber would not last as long, not more than half as long, as using brimstone. It would also cost more to attend to it, but now a boy looks after ours at 60 cents a day. If we were burning pyrites we would require the service of a man to see that it was burning properly. I do not know what it would cost now to buy the sulphuric acid. Some three years ago we bought some at Brockville and it cost us about two cents a pound. Now it costs us to manufacture it about 70 cents per 100 lb. ; that is the equivalent of the concentrated acid, but we do not concentrate. If we bought it, it would cost us about $2, whereas we make it now for 70 cents. We use some 65 per cent. phosphate ; that costs us about $8 at the mine, and the freight is about $1, making with the cartage about $9.30 at the works. We will not take anything under that. We have to get a grade that will make a certain percentage of soluble, and if it goes under 65 per cent. it will not answer ; if we get a stronger grade of phosphate we have to fill in. The high grade, that is 84 per cent., costs $17.50 at the factory. The ammonia we use costs $60 a ton. Ground leather and wool waste, which will give the same analysis, can be had for $5 a ton, but they are of no use for plants. The law does not recognise that at all. We could use that material and save some $53 or $55 a ton and the chief analysist could not find fault. I think an affidavit should be required, stating in what form the ammonia was. As the law now stands great frauds are possible.

Superphosphate as a fertiliser.

Raw materials.

Sir James Grant—I look upon the phosphate industry as one of great importance, and one which is but in its infancy yet. Recent investigation has shown that finely ground phosphate of lime sprinkled upon the ground is extremely fertilising, though not so immediate in its effects as superphosphate. One company contemplates using the sulphur from the Sudbury district to manufacture sulphuric acid, and to establish large works at Buckingham for the treatment of phosphate, with the idea of shipping it in its manufactured state as superphosphate to England. There is no reason why it should not be chemically treated in this country. At present they are grinding up the second and third quality apatite at Buckingham and shipping it to Chicago, where it is mixed with the refuse from the slaughter yards and manufactured into some kind of manure. I think the United States will be the best market in the future. The phosphates of Carolina are of very low grade compared with ours, being only from 25 to 50 per cent.

Importance of the phosphate industry.

Byron S. Walker—We have pyrites from which sulphuric acid might be made to treat our phosphates. A large business might be built up with the southern states in phosphates and superphosphates, if the freights will allow of it.

Trade.

PLATINUM.

Though platinum has not yet been found in any workable amount, a notable quantity of a hitherto unknown compound of this and other metals of the same group with arsenic has recently been produced at Vermilion mine in the township of Denison. The compound is a heavy white metal of a composition as given by Prof. H. L. Wells, of Yale—

A platinum compound.

Arsenic	40.98	per cent.
Antimony	.50	" "
Platinun	52.57	" "
Rhodium	.72	" "
Paladium	trace.	
Iron	.07	" "
Oxide of tin	4.62	" "
Total	99.46.	

The formula $PtAs_2$ has been given to this mineral, as it is amorphous with FeS_2, and the name of sperrylite (after Mr. Sperry, the chemist of the Canadian Copper company) has been given to it. We tested some of this mineral with a blow-pipe in August, during our visit to the Vermilion mine, and found it readily fusible, giving off no fumes and leaving a white bead, slightly yellowish, which was quite brittle when hammered. The sperrylite is obtained, together with gold, from the decomposed gossany matter lying about the diorite mound from which the copper ore is taken at shaft No. 1 of the Vermilion mine. This gossan is run through the prospecting stamp mill for the gold it contains, and the sperrylite is caught on carpets.

Sperrylite.

PLUMBAGO.

A deposit of plumbago has been discovered in the township of North Elmsley, in the county of Lanark, to which reference is made in the evidence. The process of treatment of the ore is given by Mr. Vennor in the Geological Survey report, 1872-73, page 178.

A deposit in North Elmsley.

W. L. Morris—Plumbago occurs at Oliver's ferry in massive rock, about 40 per cent. plumbago and 60 per cent. quartz. Mr. Eaton of Charlotte worked it and made three grades—pencil and two coarser grades. I believe the reason he stopped was because he was paid not to work it. He told me himself that the first six months paid him all the cost of the machinery and a profit besides. There is any quantity of ore to be seen there now. It is in North Elmsley and is known as the King lot. The deposit is lenticular and extends over five or six adjoining lots, but not in such large masses. Mr. Eaton had a battery of 10 stamps and stamped it. The waste was sold to manufacture stove polish The property is close to navigation, within one mile of steamboat navigation and six miles of the railway. Mr. Eaton told me his prices were 6, 9, 15 and 20 cents per pound wholesale. In Bedford there are numerous veins, one in particular that will average six feet and which appears to be solid plumbago ; but a drop of acid on it will show lime al through, and this renders it less valuable. A shaft has been sunk there about 100 feet. The deposit at Oliver's ferry contains no lime.

A plumbago mine in North Elmsley.

A vein in Bedford.

R. Sherrett—The deposit of plumbago at Oliver's ferry is the largest one in the Perth district, but I never took much notice of it. There seems to be almost any quantity of it there. The whoe rock is dark and black looking and one can see graphite all through it ; 36 per cent. graphite is the best assay I secured in this district. I have seen samples from Bathurst, but the outcrops there seem to be more extensive then they really are when opened up.

The deposit at Oliver's ferry.

SALT.

The area in which salt is reported to be found in Ontario may be said to be south of a line drawn in the vicinity of Kincardine, Wingham and Brussels,

The salt area in Ontario.

and west of one drawn south from Brussels to Seaforth. The salt bed or beds run south and west into Ohio and Michigan, and developments in Ontario have chiefly taken place on the north-east edge of the beds, except where it is drilled into at Courtright, on the St. Clair river. In the borings which have been made one or more beds are met with at a distance of about 1,000 feet from the surface, varying in thickness from 20 to 100 feet. The quantity is practically unlimited and the quality is excellent.

PROCESSES OF PRODUCTION.

Dissolving the salt rock.

After dissolving out the bed of salt for some time, it is found that a cavity is formed into which the upper layers of rock sometimes fall, jamming the pump tube and taking down portions of the gypsum which occurs in the superimposed strata. This gypsum gets dissolved and bothers the manufacturers, both by forming a coating on the evaporating pan and getting into the manufactured salt, thereby to some degree impairing its quality. In the inland places the water from the upper strata follows the drill or pump tube and gives a sufficient supply to dissolve the salt rock and keep the pump supplied with brine. It appears from the evidence that this water dissolves a certain amount of gypsum in its passage through the strata containing it, an objection which, it is claimed, is overcome at the wells on the St. Clair river by forcing river water down the salt in a casing outside the pump tube. Even by the latter process, however, they are not free from the inconvenience of gypsum, and on the Amercian side a process patented by Alburger & Wilson, of Buffalo, is in use by which the gypsum is extracted before the brine is run into the evaporating pan. This is done by forcing the brine through horizontal tubes in a heater raised by steam to 280° ; thence it flows up through a cylinder three feet in diameter filled with large pebbles. The gypsum is deposited from the superheated solution in the tubes of the heater and around the pebbles, and as no evaporation takes place no deposit of salt can occur. The tubes of this heater are bored out once in two weeks and the gypsum encrusted pebbles are replaced at intervals with a new supply. After passing through the stone chamber the brine is raised to a higher degree of heat and run into an evaporating pan or "grainer," as it is here called, where the process of deposition is carried on. Revolving arms, to which trailing pieces of wood or leather are attached, are in constant motion in the evaporator, and these trailing pieces, striking the crystals of salt as they form on the surface of the brine, throw them to the bottom. By this simple expedient very fine crystals of salt are formed continuously and no grinding is necessary, although it is bolted after being dried.

A patent process to eliminate gypsum from the brine.

Ordinary process of production.

The ordinary process in the production of salt No. 2 is carried on both in Ontario and Michigan as follows : A hole about $4\frac{1}{2}$ inches in diameter is bored down until the first or second salt bed is struck, in which a tube of 3-inch. inside diameter is inserted for the pump. The cost of drilling is now about $1,500 for holes from 1,000 to 1,120 feet deep, the figure in one case being $1.05 a foot, machinery and fuel, but not tools, supplied. As a rule the driller supplies everything, including the casing to the rock. From 1866 to 1868 the cost of putting down a well ranged from $3,000 to $5,000, but with improvements in the process and with experienced workmen the cost is now reduced

Boring the well.

by about 50 per cent. Where the lake or river water is forced down through an outside tube and the brine comes up from the inside one, as at Courtright, the outside pipe is 4 to 4½ inches and the inside 2 inches in diameter, inside measurement.

In the ordinary mode of raising the brine it is lifted up by a pump making about 30 strokes per minute, lifting some 18,000 gallons a day of ten hours. For this purpose an engine of 20 horse-power and a boiler of 25 horse-power are generally used. The brine in the Ontario wells is usually 100° (one-fifth salt), the maximum of saturation. The tube reaches to the salt bed. Where not forced down the water is struck in a stratum of broken limestone at about 500 feet, and either rises to the surface or nearly so. The pump consequently has not much lifting to do. The pressure of the water running down the side of the pipe to the salt forces the saturated water up the pipe to its own level, less its greater specific gravity as brine. It is estimated that this pressure is about 500 pounds per square foot at the bottom of the tube. The plunger of the pump as a rule is put down only about 500 or 600 feet, but the tube reaches to the salt bed. The amount of brine pumped is generally double the evaporating capacity of the pans, so that no pumping need be carried on at night.

Pumping the wells.

The brine is pumped into large vats or tanks, whence it can be directed at will into the pans. The size of the average pan is about 100 feet long by 26 feet wide, and will produce about 100 barrels of salt a day; but at Kincardine there are pans 191 by 32 feet and 140 by 25 feet, which will produce from 300 to 400 barrels a day. The pans are deepest at the fire end, the large ones being one foot deep there and six inches deep at the farther end; the smaller pans hold an average of three or four inches, but the amount of salt produced by any pan of course varies according to the amount and quality of fuel used. The pan has to be cleaned from gypsum scales usually every two weeks; otherwise there would be a great waste of fuel.

The evaporating pans.

At the fire end of the evaporator the salt is deposited most rapidly, owing to the brine being heated to a greater degree in that quarter, and the salt must be continually raked back for a distance of some twenty-four feet. At this part of the pan the crystals are very fine, and are raked out about eight times a day. For another twenty-four feet or so farther on the crystals are somewhat coarser, and the salt is raked about four times a day. At the end of the pan farthest from the furnace the crystallisation is so slow that the raking is done only about twice a day, and the salt is of the largest crystals. At some of the works this coarsest salt is run through a cylindrical dryer and then ground and put up in neat sacks for table and dairy purposes, and thus prepared it is considered the finest salt. The ledge upon which the deposit is raked slopes towards the pans, into which any brine taken out drips back again, and the salt is soon dry enough for handling. When dry it is thrown into compartments which are divided off according to the various grades of salt, and usually for convenience in that portion of the building immediately on each side of the pan, and extending to the ground floor. Beyond this a side wing is built as a passage-way, etc., and here also the barrels and sacks are filled. A barrel of salt weighs 280 pounds, and at the time of the visit

Process of manufacturing the salt from brine.

of the Commissioners the ruling price was about 54c. It was 96c. to 97c. under the Association.

LOGS OF BORINGS.

Reports on salt. A valuable report on the geology and chemistry of the salt deposit of the Goderich region and a discussion of the best modes of manufacturing salt was written by Dr. Sterry Hunt in 1869, which is found in the report of the Geological Survey for 1866-69, page 211. J. Lionel Smith also wrote on the history and statistics of the trade and manufacture of Canadian salt, giving the logs of some bore holes, in the report of the Survey for 1874-75, pp. 267-300. The following logs are valuable as indicating the depth of the wells, and the stratification and general character of the salt region of the province :

KINCARDINE.—(John Tolmie.)

At 888 feet from surface struck the	
1st bed of salt	28 feet
Limestone	32
2nd bed of salt	33
Total depth of well	981
Lift by pump	600

At Port Elgin and Southampton drilled and got no salt.

GRAY & SCOTT'S WELL.—(J. Lionel Smith).

Common sand	7 feet
Yellow clay	8
Water gravel	10
Quicksand	64
Alternate layers of sandstone and limestone	28
Limestone	179
Very fine grained white freestone	29
Dark colored limestone	276
Red shale	14
Blue shale	115
Very hard blue limestone	164
Very hard cherty rock	5
Rock salt	12
Alternate layers of blue shale and clay, mixed with salt	36
Hard and pure rock salt	60
Total depth of well	1007 feet

INTERNATIONAL WELL.—(J. Lionel Smith.)

Blue clay with a few limestone boulders	100 feet
Limestone boulders and gravel	40
Alternate beds of sandstone and limestone	510
Hard flinty limestone	300
Blue shale with streaks of red shale	84
Gypsum	6
Brown limestone, soft	14
Rock salt (No. 1)	19
Brown limestone, very hard	30
Rock salt (No. 2)	24
Blue shale and blue clay	3½
Rock salt (No. 3)	32
Brown limestone, rather lighter in color than the preceding	8
Total depth of well	1170½ feet

WINGHAM.—(Wm. M. Gray.)

Depth to the salt	1140 feet
Depth of the salt bed	40
Total depth of well	1180 feet

BLYTH.—(Wm. M. Gray.)

Depth to the salt	1110 feet
Depth of the salt bed	80
Total depth of the well	1190 feet

BRUSSELS.—(Roger's well.)

Depth to the salt	1000 feet
Depth of the salt bed	40
Depth into rock below salt	30
	1070 feet

CLINTON.—(John Ransford.)

To bottom of first bed of salt, which is 18 feet in thickness	1170 feet
To bottom of second bed, which is 25 feet in thickness	1245

Before striking salt 800 to 900 feet of limestone was penetrated.

SEAFORTH.—(Dr. Coleman.)

100 feet, loose limestone, (hard and soft streaks.)
At 350 " struck water which rose to within 6 feet of the surface.
450 " " Guelph limestone.
800 " " rotten stone, (50 feet thick.)
830 " " 2 feet of very hard stone.
880 " " bed of clay, (taste salty and pockets of white anhydrous material.)
To 1020 " limestone.
1028 " salt.
1032 " porous rock containing salt.
1132 " rock salt, and did not reach bottom.
Total depth bored 1132 feet, now down at 1120 feet.

The log of one of Gray, Young and Sparling's wells at Seaforth gives a depth of 1050 feet to salt and 90 feet into the salt. Total depth of well 1140 feet. About 40 feet of loose material was found above the bed of salt and 30 feet of mixed salt and shale.

MITCHELL.—(Peter McEwan.)

At 1200 or 1400 feet light reddish brown shale rock, and still in that when boring stopped at 2000 feet. The material was the same as in the Goderich hole, except that the limestone was 100 feet thinner. There was no salt, but a white clay resembling pipe-clay where salt should be, and of about the same thickness.

GODERICH.—(Peter McEwan.)

In 1866, bored in river valley, (clay 30 feet), 1000 feet to salt.

In 1868, bored on table land, (clay 120 feet), 1130 feet to salt. In the latter passed through 30 feet quicksand, 90 feet blue clay, 5 to 10 feet of gravel or hardpan.

ATTRILL'S WELL.—(Dr. T. Sterry Hunt.)

	FT.	IN.
Clay, gravel and boulders	78	9
Dolomite with thin limestone layers	278	3
Limestone with coral, chert and beds of dolomite	276	0
Dolomite with seams of gypsum	243	0
Variegated marls, with beds of dolomite	121	0
Rock salt, first bed	30	11
Dolomite, with marls towards the base	32	1
Rock salt, second bed	25	4
Dolomite	6	10
Rock salt, third bed	34	10
Marls, with dolomite and anhydrite	80	7
Rock salt, fourth bed	15	5
Dolomite and anhydrite	7	0
Rock salt, fifth bed	13	6
Marls, soft with anhydrite	135	6
Rock salt, sixth bed	6	0
Marls, soft, with dolomite and anhydrite	132	0
Total depth of well	1517	0

Farther south the brine is blackish, with more of sulphur, and has to be settled at 150°, when it is drawn off, boiled and evaporated. The limestone also gets thinner.

PORT FRANKS.

At this place, about 40 miles south of Goderich, the well is 1345 feet deep.

BOTHWELL.

The salt bed is similar to that at Goderich, but deeper and thicker.

PARKHILL.

The same salt bed as at Goderich.

PETROLIA.

Similar bed to that at Goderich, but more salt.

COURTRIGHT.

Struck salt at	1620 feet
First bed of salt	21
Bed of salt below, but not reached here.	
Mineral water vein struck at	836
Casing put in for	876
Depth of pipe	1646

PETROLIA.—(Lot 3, con. 11, Ennisklillen.)

Surface clay	104 feet
Limestone	40
Shale	130
Middle limestone	15
Lower shale	43
Hard white limestone	68
Soft " "	40
Big limestone or oil bearing rock	25
Grey limestone, with salt water	28
Grey limestone, containing more or less water	107
Hard white limestone with strata of sand varying from 2 to 5 ft	500
Gypsum	80
Salt	105
Gypsum	80
Salt	140
Total depth of boring	1505

COMBER.—(Lot 7, con. 1, Tilbury.)

Surface blue clay	93 feet
Sand	27
Very hard rock (with iron pyrites)	53
White limestone (bitter water)	110
Sand rock, (show of oil)	20
Limestone	200
Sand rock	10
Soft limestone, salt water, (cased into this limestone)	76
Hard limestone	23
Freestone	35
Soft limestone	27
Hard limestone	12
Soft limestone	34
Hard limestone	22
Shale, with hard streaks	100
Soft limestone	12
Hard limestone	125
White limestone, streaks of shale	50
Bluish limestone	10
Hard rock, with streaks of shale	55
Very hard rock (with iron pyrites)	25

Hard limestone	116 feet
Hard limestone	40
Limestone, good cutting	10
Total depth of boring	1285

St. Clair, Mich.

To top of salt	1635 feet
Bed of salt	40
Lime rock and salt, alternate layers	70

At 730 to 800 feet brine or mineral water was found, but no salt.

Marine City.

To top of salt	1675 feet
Salt and rock in alternate layers	110

Dr. Timothy Coleman—I was the first to discover salt at Seaforth. We made salt about Christmas, 1869, and before May, 1870, we had two pans; a third one that we put up got burned. At that time the market was better than at present. We got $1 and $1.20 a barrel; now it is 50 and 55 cents, with the price of wood gone up. The price of the barrel is about 22 cents, we pay 2½ cents for packing, and it takes about a cent's worth of nails to a barrel, so that we have about 30 cents for the salt. We have two pans, 24 by 110 feet. The capacity of a pan is about 100 barrels a day. About two million sacks of salt come over annually from England. I contend that English salt should be excluded; the demand then would keep us all going. At present the total amount produced in Ontario is about 400,000 barrels. We could easily produce the total amount that is now imported from England as well. We are driven out of the market so that the fishermen in the eastern provinces may have free salt, and we cannot use their coal. I do not think that is fair; we should have free coal. We have better salt than the Americans. Our brine is the purest in the world, being 98 per cent, and the quantity here is unlimited. With free trade we could compete with the Americans. The American manufacturers are getting 60 or 70 cents a barrel. The best remedy at present would be to keep out the English salt and give us our own market.

Cost of a barrel of salt.

English and American competition.

William Grey—I have been engaged in manufacturing salt for about seventeen years in Seaforth. We have three wells, one here (Seaforth), one at Wingham, and one at Blyth. The one here was bored seventeen years ago, the one at Blyth ten years ago and the one at Wingham two years ago. From the surface to the bottom here is about 1,140 feet; there was about 40 feet of loose material. We did not keep a log of the well, or samples of the drillings. Before getting into the salt in all the wells we got into a kind of shale; there was about 30 feet of shale and salt mixed. I think it is all the same bed of salt. The main bed is 90 feet through, and there are supposed to be beds below that again, but we have not gone under that bed here. At Clinton they are supposed to have gone through to a second deposit. The main bed seems to be thicker here and at Blyth than anywhere else. At first, seventeen years ago, we made here at the rate of 25,000 barrels a year; the greatest activity was about 1874 and 1875, when we made about 60,000 barrels a year here. Last year we made 10,000 barrels. The works are now about shut down, but not for the want of a supply, for there is plenty of brine. We have abandoned our well here on account of the falling off in quality. I do not know what it is that is coming into the brine, but it increases the cost of production very much; we think it is caused by the size of the cavity, and the distance the water has to travel through other rocks. Of late we have made only a little for the retail trade here. The barrel of salt weighs 280 lb. net. The cost of a barrel is about 20 cents; we make our own. When the salt industry started here first we paid 32 cents for barrels. If we had to buy them now they would be worth about 25 cents. When filled with salt we get from 55 to 70 cents; that has been the price for about three years I think; it was 50 cents for a couple of years before that. We make table salt at Blyth, but not here. We have only one pan here, 20 by 120 feet. It is capable of making 150 barrels a day, the quantity depending on the amount of fuel used. We have been using beach and maple at $3 a cord, and soft wood at $1.25 and $1.50. The brine is very strong, being full saturation. We commenced at Blyth ten years ago and struck salt at 1,190 feet; the formation is about the same as it is here, and we are supposed to be working in a bed 90 feet thick. We have two pans there, and a mill for table and dairy salt; the pans are 24x130. For grinding the table salt we use steel rollers. We make about 15,000 barrels a year of table and dairy salt, put up in small bags which are packed in barrels. The bags cost from $1.30 to $2 the barrel. In bulk

Salt wells at Seaforth, Blyth and Wingham.

Capacity of Seaforth well.

Cost of production.

The Blyth works

that salt is sold at 85 cents a barrel. Our total production at Blyth runs up to about 50 000 barrels a year. We went there on account of cheaper wood ; labor is about the same as here. Cheaper fuel was the main object at that time, but now we find the salt is purer there. **The Wingham well.** At Wingham we sank in May, 1886, and struck salt at about 1,140 or 1,150 feet. We did not drill that well ourselves, and do not know what the bottom is like. It is two miles from the village and we have to pipe the brine that distance. The Wingham well is the only one on the line of the Canadian Pacific railway, and that gives certain advantages in freight to local points. At the three places we have about 40 men employed directly in connection with the salt business, including those engaged making the barrels. We bought 5,000 cords of wood at Blyth last year, and 2,000 cords at Wingham. That gives a great deal of work cutting, teaming etc **Extent of the salt deposit.** The salt deposit extends a couple of miles east of here. There is plenty a mile and a quarter east, but six miles farther east there is no salt, while everywhere west where well-borers have chosen to go deep enough they have found it. Brussels is on the outer limit of the deposit towards the north. The roof over the salt is falling in at some wells, but there is no inconvenience on account of that. There is no movement on the surface at all. The water and the loose stuff act as a support. In all the wells sufficient water finds its way down to give any quantity of brine. **English competition.** The great difficulty the Canadian salt trade has to contend with is the importation of English salt. It comes over as ballast, and is then brought to Toronto at $ 1 a car. The freight from here to Montreal by the Grand Trunk is $36 a car. There is no duty on the English coarse salt, but there is upon table salt. We ship table and dairy salt to the eastern provinces. About two million bags are imported from England every year. Our production is about 350,000 barrels A good deal of English salt is shipped from Kingston to Chicago as ballast. Competition has reduced our capital 60 per cent. in value, and of late years it has not been a profitable business. From 1878 to 1883 we had five years of fine business. We had just started the Blyth works and had cheap fuel for two years, and for the next three we had the Association and that put the price up high. **Land salt** There is not as much salt used now as there was five years ago on the land. The reason of that is, I think, because the farmers cannot afford to buy it on account of the poor price they have been getting for their stuff. We sell a couple of carloads a month to the chemical works at London.

The Brussels well. *F. C. Rogers*—I reside at Brussels and my business is that of merchant and salt dealer. The depth of the well, which I sank seven years ago is about 1 070 feet. The salt was struck at a depth of about 1,000 feet the bed of salt being about 23 feet thick. There was fresh water all the way down. The works were started in September, 1881. We pump about 18,000 barrels of brine per day, and our product is about 25,000 barrels a year. We make both dairy and common salt. **Cost of production.** We sell common salt at 60 cents a barrel. Dairy salt is put up in 3. 5, 7 or 10 ℔ bags, and I suppose it would average $1.50 a barrel. Barrels cost us about 20 cents each Our market is as far east as Quebec ; we sent a car of dairy salt to Quebec **Markets.** yesterday Our common salt does not go much farther than Brockville or Prescott. I do not think that any salt comes from the States. There should be a heavy duty on English salt ; there is a duty on fine English salt, but that does not amount to anything. We sell more dairy than any other kind. The coarse salt comes principally from England. A large quantity of dairy salt also comes from England, put up in 56 ℔ sacks mostly. An enormous quantity of English salt comes over as ballast, but our salt sells in Ontario better than the English. **Plant of the works.** Including the cost of sinking the well the whole plant cost about $10,000. My pan is about 26 by 100 feet, about two feet deep on the slope and is made of quarter inch boiler plate. We make about 100 barrels a day, but do not work on Sundays. Sometimes we have made as much as 120 barrels a day. We cannot run all the time, as we have to stop at times to make repairs and particularly to clean off the gypsum coating which forms on the pan. A short time ago we had to shut down a week for repairs. **Labor and wages** We have about 15 hands employed altogether ; the man who attends the pan gets $1.25 a day ; the coopers, of whom there are two, get $5\frac{1}{2}$ cents a barrel ; the engine driver gets $1.50 a day and he also runs the dairy mill. We like the iron grinder better than the granite roller. Our grinder will do about eight barrels an hour **Production.** and we never work it more than eight hours a day. The amount of salt produced in Canada is about 400 000 barrels a year, and the business is capable of being **Salt as a fertiliser.** extended indefinitely if we have a market. Two years ago we sold a large quantity of salt for manure, but farmers seem to have lost confidence in it, or it may be because they are hard up this year. I think it is one of the best things that can be put on the land ; it helps to kill vermin. The price of land salt is about $2.50 a

ton. We also sell a large quantity for tanning hides and salting pork. Our salt was tested against the English salt in London and found to be better. I think this is about the edge of the salt basin here. A well was bored east of us, but no salt was got. West of Brussels it gets thicker, and at Blyth it is 90 feet.

The salt area.

John Tolmie—I am secretary of the Ontario People's Salt Manufacturing Co. of Kincardine. It is a farmers' institution. Salt was first found in Kincardine about twenty years ago, I think. There are three wells belonging to the company. Salt was struck at a depth of 888 feet, and the first bed is 28 feet thick; then there is 32 feet of limestone rock, and below that another salt bed 33 feet We supplied the machinery and fuel and the boring cost us $1.05 per foot. The length of our pump is 981 feet, but the pressure of the water going down lifts the brine up a certain distance, so that we have to pump it only about 600 feet. We have one pan 191 by 32 feet, and can make from 300 to 350 barrels a day according as we fire. When the pan is full there is a foot of brine in front and about six inches at the farther end. The front part of the pan, where the heat is intense, is made of steel, but the back part is iron. We use slack coal for fuel, half bituminous and half anthracite. The salt is very pure and we do not require to use anything to purify it. At some of the works they use chemicals to take out the gypsum Last year we produced about 2,000 tons put up in barrels and bags. It was all sold in Ontario; none went to the States. We did not make any more because the price was so low. About 300 tons was land salt, 400 tons coarse salt and the rest fine salt. The coarse clean salt is made at the back end of the pan.

Salt wells at Kincardine.

Depth and thickness of the salt beds.

Production and market.

John Ransford—I reside at Clinton and am a salt manufacturer. The first boring for salt was commenced at Goderich about 1866, and at Clinton about the beginning of the following year. My brother Richard commenced to bore about 1867. We first went down 1,170 feet from the surface; that is the bottom of the first bed. Since then we have bored below that, down to 1,245 feet. We went through the underlying stratum, composed partly of hard limestone, and then into the second bed of salt. The first bed we estimate to be 15 to 18 feet, and the lower bed about 25 feet. The rocks here I believe to be about the same as at Goderich; between the surface and the first salt there is 800 or 900 feet of limestone. There are only two wells here, and the depth of the other one is about the same as ours. I do not think the other well has been worked since the beginning of 1886. The demand within the last two or three years is falling off. I think there is a falling off in consumption, and there is also more imported. There is not as much salt sold for the land as there used to be. Since I started to make again in the month of April this year my output has been about 30 carloads a month. For nine or twelve months before that we had a good deal of trouble with our well, owing to the falling in of the roof; we had to take the tube up and had a great deal of trouble in getting it down again. As we have been working the well for about twenty years we think we have a large lake below. The roof had fallen and formed a heap that obstructed our tube, and knowing the nature of the overlying rock we conjectured the brine would be more or less impure; so we bored down past this obstruction on into the second bed, which we knew by Dr. Hunt's report of Attrill's boring was of exceptional purity; according to his report it was the purest rock salt known. We went into it about 25 feet and stopped there because the boring at Goderich showed that to be about the thickness of the second bed. We were still in salt when we stopped. By having an outer casing outside our pump and resting on the ledge of solid rock below the obstruction referred to above, we prevented any of the impurities from getting into the pump. But just as we got it in working order the casing slipped off the ledge. We had great difficulty to get it out again—it took us about seven months—so that we were out of the market from September till March. We get good brine now and make good salt. My present output is from 25,000 to 28,000 barrels a year. In former years I exceeded that. I have two pans, 80 or 90 feet long by 30 or 40 wide. We generally keep about three or four inches of brine in the pans. The pans have to be cleaned about once every two weeks. We do not pump all the 24 hours, as we have tanks which hold the brine required during the night. I think there is less scaling of the pans since we have been pumping from the new bed. In 1866 and 1867 it cost much more to put down a well than at present. Now it can be done in a quarter of the time and for half the money. We are under the impression that this bed extends into Michigan as far as Manistee. To the east it has been tapped at Seaforth, but at Mitchell they could not find it. It has been struck two miles this side of Dublin, and that appears to be the eastern limit of the bed. At Teeswater they could not find it. I understand that at Wingham they bored

The Clinton wells.

Production and consumption.

Boring into the second bed.

The salt area.

and could not find it; then they bored two miles west, in a line between Brussels and Kincardine, and there they found it. Speaking as a protectionist, I say the salt manufacturer of Canada should be protected; he should have the Dominion for his market. Practically, everything we use is protected up to the handle; the only thing we can import free of duty is the fire brick. English salt is brought over as ballast and is admitted free. It is brought to the west for less than half the rate we have to pay on salt going east. I pay $21.60 a car of eighty barrels from here to Toronto. The freight on English salt from Montreal to Toronto is $12. I have not the least desire to see salt taxed that is imported for the use of fishermen. But as a matter of fact it is not used for that purpose alone: it comes to Toronto and enters largely and principally into competition with our land salt. And I have good reason to believe, too, that this English salt is ground in this country, put into small bags and sold in competition with us as dairy salt. Besides the coarse salt there is a large quantity of fine salt sold under different brands, such as Higgins, Eureka, Ashton, etc.; whether that pays duty I do not know, but it comes in and is sold, and from the amount that is sold I doubt whether it does pay duty. There is a duty on fine salt of 10 cents per 100 lb.

Competition and protection.

Peter McEwan—I reside at Goderich and my present occupation is that of salt manufacturer; I am also a driller. This summer I drilled four artesian wells for the town, two of which were eight inches bore. The first salt well was drilled in 1865, and was bonused by the municipality. It was bored to a depth of about 1,000 feet. The North American Chemical works here make principally dairy salt. John Platt manufactures about 20,000 barrels a year, but of course could make far more. I make from 20,000 to 25,000 barrels, and if I had a market I could make twice that. Joseph Kidd, jr., makes about 20,000 or 25,000 barrels. Ogilvie and Hutchinson use their exhaust steam and make about 7,000 or 8,000 barrels a year. Of course they could produce a great deal more. The well I work was only drilled through the first bed of 16 feet, and there we get all the salt we want. After reaching a depth of 600 or 700 feet I think the rock is perfectly dry; the first 700 feet supplies all the water. The first wells drilled here were $4\frac{1}{2}$ or 5 inches diameter. The best way is to put in a bit and drill the full size at once. We use a three-inch pump. The pressure of water is half a pound to the foot, so that 500 pounds would be the pressure in a 1,000 foot well. The water goes down through the casing outside the pump and comes up through the pump. The $3\frac{1}{2}$ inch pump goes down about 500 feet and we have the working bucket there, the water going down on the outside forcing the brine up to that height. In Marine City and at other places on the St. Clair river they force the river water down between outer casing and inner pipe, thus forcing the brine to the surface. They do that as the river water is much purer. Of late years there have been great improvements in the system of boring and the cost is now about one-half what it was twenty years ago. There is some salt used on the land in this neighbourhood, but it is very little; I cannot tell you the quantity, but not as much as some years ago. Most of the salt sold by Ogilvie and Hutchinson is for that purpose. I don't sell more than 200 to 300 tons of land salt a year; Mr. Platt and Mr. Kidd sell about the same, and the Chemical works not as much—perhaps 2,000 tons a year in all. More salt is used in the neighborhood of Whitby and the bay of Quinte, but here the country is new and the farmers have not very much money.

Producing Goderich works.

Pumping the wells.

Land salt.

Joseph Williams—I am a lumberman and am also engaged in the manufacture of salt at Port Franks. The well was sunk in 1883 and is the only one there. It is somewhat deeper than the wells at Goderich, though we commenced there on a level with the lake. As far as I recollect the well is about 1,345 feet deep, but I cannot tell you the thickness of the salt bed. We do not work more than three or four months a year. We have a saw-mill and work the salt well in the summer months in connection with the mill. Three or four months output supplies all the salt we can sell now. If the price would justify it we would run all the time. I suppose there are between 6,000 and 7,000 barrels of salt lying there now, and there is no better salt. When we pump up the brine it is black, caused I understand by sulphuric hydrogen gas. When warmed the foreign matter falls to the bottom, and then we allow the brine to go into the front part of the pan. We lose about 25 feet of our pan on that account. We have one pan, 125 by 25 feet. In connection with the works we employ twelve men and one span of horses. We have a large boiler that supplies steam for the saw mill and for the small engine that does the pumping. Our pumping engine is about 15 horse power. Our pump is about 650 feet down from the surface. Four wells could supply the Ontario demand, and we have not the market of our province on account of English salt.

Port Franks well.

James Carter—The Courtright Salt Co. is an incorporated company with a subscribed capital of about $6,300 ; J. S. Nesbitt of Sarnia is the president, and I am secretary-treasurer. Salt was first discovered here on the 30th June, 1884, and ours is the only well. It is 1,620 feet deep to the salt, there is 21 feet of salt and it goes five feet under, making the total depth 1,646 feet. Beyond that it has not been tested here. On the other side of the river, after passing through a bed of salt corresponding with ours, they found another bed of salt 30 or 40 feet through, with just six feet of rock between the two beds. At 836 feet we found mineral water the same as they use across the river for bathing and drinking purposes. The well is cased to 876 feet with iron casing four inches in diameter ; inside of that there is a two inch iron pipe running to the bottom of the bed and this pipe is perforated at the bottom. The river water is forced down between the two pipes, and after becoming saturated with salt it is forced up through the inner pipe. Forcing the water down in this way takes about the same amount of power as pumping the brine up in the ordinary way. Our engine is about a 12 horse-power. The advantage of the system is that we can shut off the water that may contain impurities and force down water the quality of which we know. For the first week or ten days the brine was not very strong, but since then it has been of the full strength. We have not had any trouble on account of the caving in of the rock ; the drillers reported solid hard rock to the top of the salt rock, so we do not anticipate any trouble of that kind. From 876 feet it is said to be a solid hard rock right down to the salt. Our pan is 20 by 50 feet and the salt has to travel the length of the pan three times. We make a hundred barrels a day, but we have made as high as 128 barrels a day for a week at a time. We made about 28,000 standard barrels last year. This year we do not expect to make over 25,000 barrels as we have been shut down a longer time ; we were shut down four weeks last year and about eight weeks this year. The demand has been less this year. Last year our output averaged about 54 cents a barrel. The price would be about the same this year till the 1st of June, when we advanced it 10 cents a barrel. We are not in any association, there was a lake shore association, but it is not in existence now. The Canada salt association ceased to exist on the 29th of March, 1885. Under it each manufacturer was alloted a certain amount and for about two years the price obtained was 96 or 97 cents at the works. But owing to disagreement as to the allotment the association fell through at the period stated, after an existence of about three years. At the time that association was in existence English salt was being imported as now. The government was asked by some of the manufacturers to put a duty on foreign salt, but they refused to alter the duty on English or American salt used for fisheries, which is free. I think it is fair that English salt should be admitted free for the use of the fisheries, and for that matter for the use of the eastern provinces, because the freight on the salt to get it there would be too high. As the law now stands salt coming from the States is free for fisheries, while salt coming from England is free for all purposes. I am told by one of our company that Walker & Co. of Aylmer, in western Ontario, use English salt altogether in packing their meat. There is English dairy salt selling in Sarnia now, and within my knowledge English salt was largely shipped to Sarnia, Chatham and Windsor within the last ten years. Mr. Ballantyne of Stratford told me he satisfied himself that we had as good salt here as the English, and he got manufacturers to make cheese from each kind of salt. The cheese was tested at a meeting without knowing which was manufactured with the English, or which with the Canadian salt, and without a single exception they decided the best was made with the Canadian salt. Since 1885 we have been using petroleum tar as fuel, brought from Petrolia. Prior to the first of June the tar cost 40 or 45 cents a barrel at Petrolia, but since that time they have raised the price to 70 and 75 cents a barrel, which makes it as expensive as coal would be. I may say that at the present time the question of the duty is a material consideration with us in not using coal. We work night and day and employ about nine men ; four men manufacturing the salt, two packing and two or three making barrels. We pay $1.25 a day to the men manufacturing the salt, 2½ cents a barrel for packing and loading it upon the cars or vessels, and 2½ cents apiece for making barrels. We make just one grade of ordinary fine salt, and our market is altogether in the province of Ontario.

Salt well at Courtright.

The pumping system.

Production.

The salt association.

Foreign competition.

Quality of Canadian salt.

Petroleum tar for fuel.

Labor and wages.

SILVER.

The Port Arthur district, extending from Thunder cape and Silver islet to Whitefish lake, is a section of country occupied by the black shales, cherts and dolomites of the Animikie formation. These shales rest uncomformably

in a horizontal position on the Huronian formation, and they are capped in large areas by a thick overflow of trap. A great number of veins occur in this district, cutting through the various series of rocks as far as followed, and generally occurring in a fault which has thrown the beds on one side of the vein above or below those on the other side. The line of fault and presence of a vein may often be noticed by an indentation in the escarpment, visible for miles away. Sometimes the veins cross intrusive vertical dykes, as at Silver islet. The capping of trap has prevented the weathering down of the underlying shale, so that generally it is only at the escarpment formed where the over-lying trap occurs that it is possible to see the veins.

Animikie formation.

The components of the veins in the district south-west of Port Arthur are chiefly calcspar, quartz (and also as amethysts), fluorspar, heavy spar, and breccia of the wall rock. They carry iron pyrites, galena, zincblende (often rich in silver), with native silver near the surface and silver sulphide or argentite below. The galena is not argentiferous as a rule. Saponite and asbestos or "mountain leather," and talcose slate also occur with the vein matter in places. The veins run in different directions, but the majority are east and west. None appeared to have any decided advantage over the others on account of the direction of their course, although, of the richest developed thus far, Silver islet strikes north and south, the Beaver north 40° east, and the Badger north 20° east. At least seventeen locations, including mines, claim to carry silver. It may be said of this district, judging by the work that has been done already in it, that the prospect of a rich and permanent yield of silver is remarkably good. In fact it would be difficult to conceive a more promising silver-carrying region.

The vein matter.

Course of the veins.

Beaver mine is situated on Beaver mountain, in the township of O'Connor, about $11\frac{1}{2}$ miles from the Canadian Pacific railway, and a short distance from the new Government road. The vein strikes north 40° east, and dips from 5° to 18° from the perpendicular. It cuts through the trap above, which is 40 or 50 feet in thickness, and below that it cleaves the

Beaver Mine.

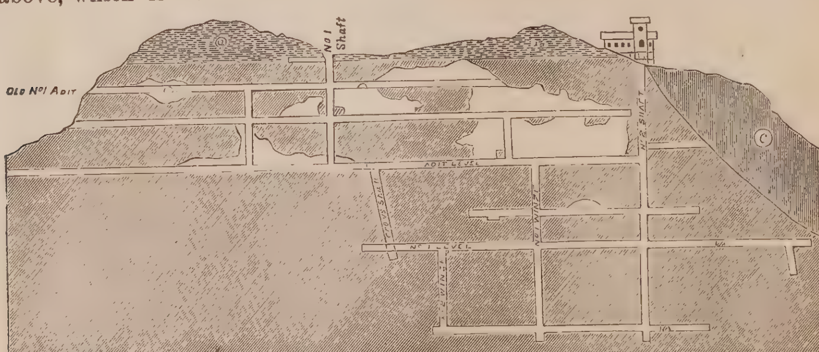


FIG. 30.—Shafts, adits and levels of Beaver mine. Scale—250 feet to 1 inch.
a. Trap. c. Soil.

black slates which form the walls on both sides. The slates, which are generally found lying in a horizontal position, are tilted upward immediately beside the vein, which contains in places a good deal of brecciated slate matter

There probably has therefore been a fault and a vertical movement downward on both sides, one after the other. The vein averages about $2\frac{1}{2}$ feet in width, varying from a mere crack without any contents to vein matter 3 to 4 feet wide. The ore deposits in the vein are met with quite unexpectedly. As the vein has been worked to a considerable depth the sulphide has for the most part replaced the native silver, which was the chief ore higher up. The silver generally occurs on the hanging wall. Where occurring with zincblende the silver is held in leaf form through the blende crystals, but when found with galena it is intimately mixed. Information about the equipment of the mine, work done, wages, etc., is fully set forth in the evidence of the superintendent, Captain Hooper.

Badger mine.

Operations on a mining scale had just commenced on the Badger property but a short time previous to the visit of the Commission. The ground was being opened up by shafts and levels, but stoping had not yet commenced. The vein is pinched in the trap above, but opens out wider in the slates below, and averages two feet wide. The strike is north 20° east, and the dip 70° south-east. Most of the ground thus far opened is very rich, silver being present where the vein cuts the trap as well as where it has the slates for walls. The selected ore is said to run up to $3,000 per ton, and, like ores from the other

FIG. 31.—Shafts and levels at the Badger mine. Scale—200 feet to 1 inch.
a. Trap. b. Shales.

producing mines in this district, it is sent off in barrels to the smelter. The shaft is being sunk 10 by 6 feet and the drifts 7 by 5 feet. A striking fact in natural history was pointed out which assists the prospector on covered ground, viz., that pine is chiefly found growing on the trap, and poplar on the black slates. The line marking the trees and the rocks is quite clear and well defined here. Fig. 31 is a section of the work done at the Badger. Full information about the mine is given in the evidence of Herbert Shear, the superintendent.

East Silver Mountain mine

The course of the Silver Mountain vein is east and west. It cuts trap and slate and has been followed into the cherty limestone below. The cherty limestone is met 55 feet higher on the north than on the south side, and therefore there must have been a fault, the vein forming in the fissure caused by it. This vein is being opened by adits driven into the escarpment, which here rises nearly 300 feet. The vein has also been opened on the low ground to the east by an open cut, and is four to six feet wide at that point. The gangue is of calcspar, carrying silver and zincblende. Iron pyrites and galena are also found. The ore is native silver and argentite, and the best rock at this

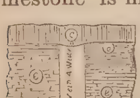


FIG. 32.
a. Shale. c. Earth.
e. Cherty limestone.

opening is found on the hanging wall with calcspar. The ore is also found in fluor and heavy spars, which occur in the vein to a considerable extent. Captain Trethewey states that in the part of the vein exposed by the open cut one-third of the vein stuff is mill rock. The evidence of Mr. Tretheway can be referred to for full particulars about this mine, and that of Captain Nicols for West Silver Mountain mine.

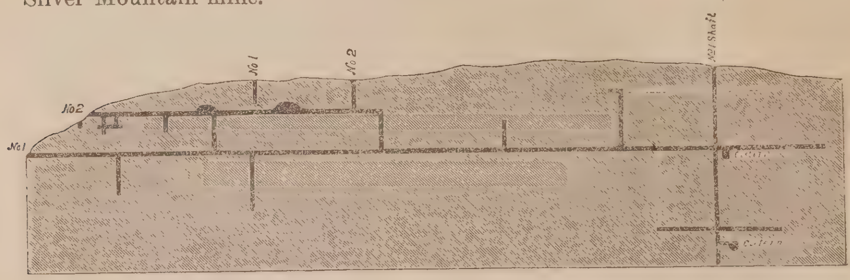


Fig. 33.—East Silver Mountain mine. Scale—400 feet to 1 inch.

E. B. Borron—In reference to silver, its occurrence on lake Superior associated with native copper can hardly have escaped the notice of those rude miners who excavated what are known as the Indian diggings. Messrs. Foster and Whitney, U. S. geologists, in their report submitted to Congress in 1850 say: "None of the early explorers seem to have noticed the existence of metallic silver associated with the copper, although we know that among the numerous masses of copper which have been picked up on the shores of the lake, some have contained a considerable quantity of silver interspersed through them." Referring to Alexander Henry (already mentioned as engaged in copper mining about 1770) they say: "Henry concludes from the result of his unsucessful experiment in mining, that the copper never can be successfully mined except for local consumption and that the country must be cultivated and peopled before this can take place. He then goes on to remark, 'It was in the hope of finding silver in sufficient abundance to make the speculation profitable that the works were commenced.' He speaks of the discovery of the metal in only one place however, Pointe aux Iroquois, where according to his authority a Mr. Norburg, a Russian gentleman acquainted with metals, discovered a blue stone eight pounds weight, which was sent to England and found to contain 60 per cent. of silver." Pointe aux Iroquois is about fourteen miles above Sault Ste. Marie, on the United States side. If this be true, the stone in question was probably found in the drift and had been transported from some point on the north or Canadian side of the lake. In 1852 a French Canadian named Secord stated that about 1824 he had discovered a mass of white metal on the north shore, from which he cut off a piece with his axe. He did not know what it was at the time, but on showing it to Capt. Bayfield or some of the party then employed on the survey of lake Superior, was informed that it was silver. Relying on his story an expedition was fitted out shortly after my arrival at the Bruce mines. The late Alexander Cameron of Sault Ste. Marie was in charge. Secord piloted the party to Thunder bay, but after the lapse of a period of twenty-eight years he could not find the exact position of the vein, and the party returned to Bruce Mines disgusted. Secord was regarded as an imposter by some, and by others as laboring under a delusion. But in the light of subsequent discoveries in that district it is likely that such suspicions were unmerited and unjust. Be that as it may, poor Secord hung himself shortly after the return of the party. In 1866-67 the discovery of silver-bearing veins by the McKellar brothers and Mr. George McVicar of Fort William once more attracted attention to the north shore of lake Superior. The existence of silver in the veins of native copper had long been known. Now it was found in the form of ore as well as in the native state, in veins that might properly be called silver veins. The excitement was greatly increased by the result of the re-examination of the Montreal Mining Co's location at Thunder cape by Mr. Thomas Macfarlane in 1868. In the

Early discoveries of silver on lake Superior.

A reported discovery in 1824.

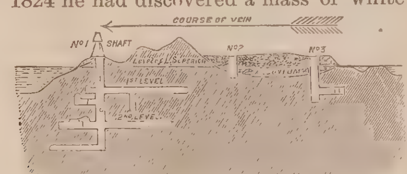


Fig. 34. Jarvis Island mine. Scale, 550 feet to 1 inch.

original description of this location by Mr. Sheppard mention is made of a small island near the shore on which there was a vein of galena and carbonate of copper. He did not seemingly notice that it contained silver as well. One of the men employed by Mr. Macfarlane found, I believe, the same vein, and he was the first to observe the presence of silver. But the credit of the discovery of silver in such form and quantity as to entitle it to be considered a silver vein is due, I think, to Mr. Macfarlane. The Thunder Bay silver mine, the Shuniah mine, 3A mine, a mine near McKenzie's river, Jarvis Island and McKellar's Island mine were, with the exception of Silver Islet, the principal mines worked while I was inspector. All of them, I think, have been unsuccessful, and as far as I know none of them are now working. Owing to the limited length of the ore-bearing portion of the vein at Silver islet a few years sufficed to exhaust the mine, and it has been for some years abandoned. Of the more recent discoveries I know nothing, unless it be that large sums have been paid to discoverers or promoters. Silver mining companies have been more cautious than those engaged in copper mining. While I was inspector the companies named were engaged chiefly in testing the veins, and but a small amount was spent on the surface until they were in a position to judge. The only exception was the Thunder Bay Silver Mining Co., who purchased and erected ore-dressing machinery before the veins had been properly tested, the result being that the money expended was thrown away. But that the managers were over-sanguine is not surprising in view of the richness of the ore in some places near the surface. The late Thomas Herrick and I estimated the value of the silver contained in one small mass of ore not exceeding 15 or 20 lb. weight at not not less than $100, and I do not think this was by any means the largest or most valuable piece obtained from the same vein. In concluding my evidence on this branch I can only say of the silver deposits on the north shore what I have already said in regard to the copper, that although like every other mining region the unsuccessful enterprises greatly outnumber the successful, yet when the extent of this silver-bearing belt, as proved by the great number of places where the metal has been found is taken into consideration, we have reason to hope that many veins as rich as that of Silver islet and much more lasting will be discovered.

Discovery of Silver Islet mine.

Unsuccessful silver mines.

A. J. Cattanach—I am a barrister, residing in Toronto. I have been interested in mining properties from 1870 down to the present time, and have been connected with the Silver Islet mine almost from the beginning. I have also been connected with several other mining properties as director, vice-president, and in other offices. I have devoted my attention particularly to the Thunder bay district, and as far west as the Shebandowan district. I have also acted for a large number of capitalists who own properties. What is popularly known as the Silver Islet property consisted of 107,000 acres of land originally owned by the Montreal Mining Co., and of lands subsequently acquired by the Silver Islet company. A large number of locations of 6,400 acres each had been patented to several individuals, and were generally called by their names. A great many of these and other locations were consolidated and absorbed by the Montreal company about forty years ago. In 1870 the Montreal company sold the 107,000 acres to Major Sibley, Captain Frue and the Hon. Edward Learned for $225,000. The purchase was completed late in the year, and Captain Frue began work on Silver islet in the same season. The Montreal company was aware that there was silver on the island; a strong report was made by Mr. Macfarlane recommending that $50,000 should be spent upon it. This report stated that the ore was not only rich, but that there was a large quantity of it. The Montreal company would not take the risk of spending so much money, and then the Americans stepped in. In the first year they produced ore enough to pay the purchase money to the Montreal company and for a large expenditure made on permanent works; and within three years from the date of their purchase they paid dividends to the amount of $360,000 besides. Then they went through some sterile rock for some time, spent a large amount of money without a return, and had to put a mortgage on the property of $400,000. After working on for about a year and a-half to no purpose they came upon rich ore again, which enabled them to pay off the mortgage of $400,000, and left them free once more. After having gone down some distance to no purpose it occurred to Captain Frue that there had been a slide or throw in the rock, and acting on this hypothesis they succeeded in finding the vein again. Meantime a company had been organised, but in the early part of 1884 work stopped at Silver islet and has not been resumed since. The shaft was sunk down 1,160 feet below the surface of the water, and the company was drifting north and south and sinking a winze to the 1,260 foot level. At that time the Canadian Pacific railway was not built, and the only way of getting supplies and

The Silver Islet property.

Successes and failures in working the mine.

Cause of shutting down.

fuel was by water. The company had ordered its supplies of fuel from the American side; but the vessels got frozen in and could not deliver the cargoes, in consequence of which work was stopped in March for the want of fuel, and the mine of course filled with water. I understood it would take several weeks to pump it out. The company had a couple of engines of 240 horse power and hoisting machinery, but

Effect of high duties on mining machinery.

the machinery was not powerful enough to go down much further, and it would be useless to commence working again without new hoisting apparatus. Shortly before operations stopped it had been decided to put in new machinery, and I was instructed to go to Ottawa and try to arrange for getting the duties taken off. The machinery would cost about $100,000 and the duties would be about $30,000. I saw the Minister of Customs, who took a great interest in the case. He appeared anxious to do anything he could to help the company, but he seemed to think nothing could be done in the way of remitting the duties without legislation. Parliament was not sitting, and it was an isolated case. He expressed his willingness to carry out any suggestions he could. It was then suggested by himself, or by me, that if the works stopped at Silver islet and the machinery was sold and exported back to the United States there should be a drawback given to the company; but that came to no practical result, because the company would have to pay the $30,000 down, and when least able to afford it. So the matter dropped and the company could do nothing. If the company had succeeded in getting the machinery at that time when it had the money, the work would probably be going on at the present day, as near the 1,160 foot level in the previous October exceedingly rich ore was struck, varying from 2,000 to 19,000 oz. to the ton. There is a great deal of machinery used in mining that is not manufactured in Canada. In the case of an English company that was going to bring some very expensive machinery to Michipicoten, I tried to make arrangements about the duty, but I could do nothing. I think that the removal of duties on machinery that is not manufactured in the country would be very beneficial. A

American capital invested.

great many Americans are interested in mining properties, and it is American money that is chiefly spent here. Silver Islet was nearly all American, the Beaver is American, the West Silver Mountain is worked by people who have come from Colorado; the East Silver Mountain is English, and the Jarvis Island Co. is English.

Product of the mine.

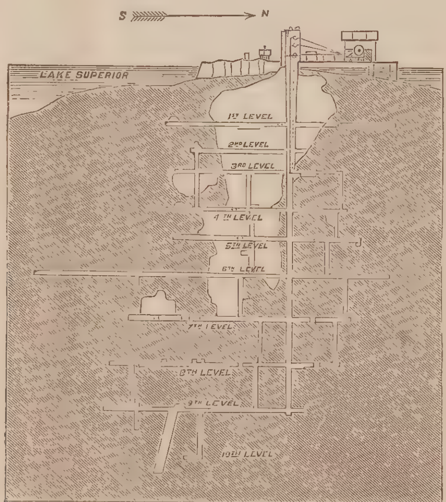


Fig. 35. Silver Islet mine.—Scale 300 feet to 1 inch.

The actual amount of silver ore taken from Silver Islet during the time the company worked was $3,089,157. When I speak of the Silver Islet company I mean the original association—the first Silver Islet company and the later Consolidated Silver Islet company which bought out the other two.

Stock of the company.

Stock of the Consolidated Company was paid up stock. It is very difficult to sell any mining stock that is liable to assessment. In the case of Silver Islet the stock was paid up, but the shareholders made themselves liable by contract to pay $10 upon each share as they might be called upon by the directors. The amount of paid up stock was $1,000,000, and this liability of $10 a share made a cash capital of $400,000, as there were 40,000 shares. Most of the shareholders paid up their calls, but a minority were unable to do so. The consequence was that the company about the time it stopped operations found itself in this position: There was a mortgage on the property of $200,000, and there were

The property sold at a suit of the debenture holders.

no resources to be had from the shareholders, because some had paid up in full and some could not pay at all. The company was discouraged; it was found it would cost much to pump out the mine and to get the new machinery, and that it would be useless to go into a thing of that kind without being well provided with money. The three promoters had died in the meantime, and there was no person connected with the company who had sufficient knowledge, experience and time to take charge of it. Things went from bad to worse, and the other day a sale took

place in New York at the suit of the debenture holders. The debts of the company only amount to about $120,000, and they have about 115,000 acres of land. The whole property was sold to the debenture holders for some $5,000, but they have expressed a willingness to accept their money from the company, and steps are being taken to reorganise it if possible. When the work stopped, the vein was perfectly developed and was very promising; they were occasionally meeting with bunches of silver. The accompanying sketch shows the work done and present position of the mine. We hope to go on again, and negotiations are pending, but what the result will be it is not possible to say yet. The Silver Islet company has not thoroughly examined the whole of its locations. The Montreal Mining company had examinations made of all of its lands and had printed reports, but it made no particular developements worth speaking of. The policy of the Silver Islet Co. was to pick out particular spots where good promise of mineral was found, and prove them thoroughly. For instance, at Mamainse, just opposite the range of the Calumet and Hecla, there is apparently a rich deposit of copper on our side. An English company spent some £70,000 on an adjoining property and island. The Silver Islet company owns 11,000 acres there, and has spent a considerable amount of money in developing that property—enough to show that it is a very good property, so that nothing is necessary but to form a large company and go on and work it. It also did a great deal of work at Point Porphyry, a few miles east of Silver islet, and proved it to be a valuable location; but nothing further has been done for the want of money. Some examination was also made of the mainland in the vicinity of Silver islet. There is a streak of quartz running from Burnt island in the direction of Silver islet, and in calm weather one can see it for 200 or 300 yards under water; that is supposed to connect with Silver islet; it breaks out on Burnt island, and again on the heights on the mainland.

Policy of the Silver Islet Co. in developing locations.

S. J. Dawson—A great many silver locations have been taken up and many are now in operation in the Port Arthur district. I believe very large amounts of silver have been exported from this district. From Silver islet I understand they exported in the few years they were working from $3,500,000 to $4,500,000. That mine was abandoned on account of the water getting into it, but I believe there is plenty of silver in it yet. I understand that with proper machinery the water can be kept under control, and that it is the intention of the owners to re-open the mine. The percentages of ores vary very largely; some rich ores go as high as $10,000 to the ton, and some hardly pay to work. In this district people have always looked after very rich ores, and ordinary paying ore has hardly met with any attention at all. I would consider from 8 to 10 ounces to the ton a fairly paying ore, but they require much more than that here. The reason is perhaps to be found in the fact that they have not got the proper appliances to work such ores with economy. Systematic mining was carried on at Silver islet and is now being carried on at the Beaver mine, and preparations for such work are also being made at the Silver Mountain mines, both east and west. Where work has been done systematically it has been very satisfactory, and where mines have been abandoned and work stopped it has generally been on account of the want of capital.

Production of silver at Silver islet.

Necessity of economic mining.

Peter McKellar—Up to the present time most attention has been paid to silver mining in the lake Superior region. Silver Islet mine was closed down for the want of coal; the vessel that was to bring the coal did not come and so they had to close down for the winter and the mine filled with water. The shaft is 1,100 feet down; the vein did not play out, and they are liable to find bonanzas at any time. It is a regular fissure vein from 6 to 8 feet wide, and the formation is slate. The bonanzas were generally found where the slate came in contact with diorite. The vein occupied the line of a fault. There are places where the vein was small, but it was large at the very bottom. There was a bonanza at the surface and another at 400 feet; the latter was richer, but not so extensive as the one on the surface. Drifting was done from the main shaft. The Duncan mine was worked to a depth of over 700 feet; it did not pay upon the whole, but I think it might pay if it was followed up. They took out some very fine silver; one piece was three or four inches long by one-sixteenth of an inch thick, from where the vein cut the syenite. There was also very rich silver in the slate near the surface. I think about $30,000 was taken out, and the mill worked about a month or two. They shipped the rich ore of that mine from Port Arthur; it would go from $1,000 to $1,500 a ton—that was selected of course. The company must have spent $200,000 altogether. They followed the vein the whole depth of the shaft, and it was not lost at any point; it was strong to the very last. It is a fissure vein in a fault, with the down-throw upon the south side; the upper part of the rock is clay slate and chert. The vein

Silver Islet mine.

The Duncan mine.

matter is nearly altogether calcspar, and it carries sulphate of zinc, galena, iron pyrites, silver, native and glance. It is 12 feet wide, about vertical, and the course about east and west. The mine was operated by an American company. The reason it closed down was, they got tired spending money without getting any return. Work was abandoned about 1882, having been carried on at intervals since 1867. The depth of the shaft is about 700 feet, but they tested with a diamond drill lower than that. I have visited the Beaver mine.

Beaver mine.

The formation is black clay slate under a thick bed of trap; the slate seems to be pretty thick, perhaps 300 feet, and then it changes to a silicious slate. The owners started mining in the clay slates under the bed of trap and found nice silver here and there, but the vein was only about two or three feet wide; these bonanzas were not very extensive, but last year they struck a large one about 1,500 feet from where they entered in the drift. For a couple of hundred feet the vein was very rich and large—the rich part would go about $2,000 or $3,000 to the ton. They took out some $300,000 or $400,000 of ore, and they are still prosecuting the work. They ship the rich ore and have it smelted; at the mills they have the concentrating or amalgamating process; the common ore they reduce themselves.

Silver Mountain mine.

At the Silver Mountain mine they have got down about 400 feet. At the beginning very heavy silver was found there, but I don't think it has paid for the outlay as yet. Silver veins in this country are fissure veins cutting through horizontal slate.

Fig. 36. The Duncan mine. Scale, 300 feet to 1 inch.

Course of veins.

The Beaver vein runs north and south, and the vein at the Badger is about the same course. The Rabbit Mountain vein is north-east and south-west. The general direction of the silver veins is east and west; very few are north and south except Silver islet. The Duncan and Silver Mountain veins are east and west. I do not know of any north and south veins crossing east and west ones. There must be 16 or 20 mines working altogether. In the Jarvis island mine they are working and getting some silver occasionally; the vein is fine looking but they have got very little silver as yet. It is about the same formation as Silver islet. There is barytes in the vein, but it is only being worked for silver. It is hard to count the silver locations that have been taken up in this district, but I think there must have been more than a hundred.

Character of the ores and veins.

The character of the ore is native silver and sulphuret of silver; silver is also found combined with zinc ore and lead ore—very commonly with zinc ore. The zinc ore is very refractory. It would be easy to separate, only that the silver is very fine when it is combined in the crystals and cannot be separated by concentrating works. The veinstone is generally calcspar, but in a few mines it is quartz. The common ore is a silver sulphide and native; it is associated with galena sometimes, but the lead is not usually rich in silver. Nickel has been found with silver and lead. Different combinations of silver with arsenic have also been found. I did not see any red colored ore at Silver islet. The composition of that vein is mostly calcspar and some quartz, but there is some heavy spar. At Jarvis island there is a great deal of heavy spar, there is iron pyrites in some veins, and there is nickel in 3A mine. In a general way about here silver occurs as silver glance and native silver in calcspar, in quartz occasionally, and occasionally in heavy spar. Fluorspar is common in the Silver Mountain country. Silver will sometimes be rich in one part of a vein, and other parts will be rich in other metals with but little silver. It is not often that we find silver in heavy spar, but occasionally we do; sometimes we get it plentifully in fluorspar, and sometimes it is not in it at all. In the Silver Mountain and the Rabbit Mountain mines it is largely in fluorspar—fluorspar being there the gangue of the silver. In the Thunder Bay mine it was in quartz, and there was but very little in spar; so also in the Silver Harbour vein—it was rich in the quartz as long as the bonanza lasted.

Thomas Hooper—I have had charge of the Beaver mine as superintendent since the 17th of March last. The location is 97 T in the township of O'Connor; the area of the mine location proper is 160 acres, but we control some other locations. One-half of the capital is owned in Detroit and one-half in Manistee; none of it is Canadian.

Beaver mine.

General Alger and F. J. Hecker of Detroit and J. Peters of Manistee are the owners. Hecker and Alger bought in on the first of November last, I think. The mine was first opened about three years ago, and the total amount of money expended up to the 1st of August last was $169,288. That includes labor, supplies, machinery, construction etc., but does not include the land; that is what is actually

expended here upon the mine. We employ about 80 hands now, and that as been about the average since I came here—45 under ground and 35 above ground. The amount of silver taken out up to the present time, according to the books, is 383,630 ounces. That would represent now about 96 cents an ounce, but what they have sold has run about a dollar an ounce. It has been shipped as concentrates. bricks and smelting ores. The ore varies considerably in value; some is as high as $5,000 and $8,000 to the ton, and some hardly runs anything. The average of 454 barrels of concentrates shipped was 847 ounces to the ton, but I cannot give you a statement of the average of the mill rock that went through the mill. I think in this section for the amount of money that has been spent there is a better showing than in any district I know of. I consider the results very satisfactory. The greatest disadvantage to this district is the want of a railway to get machinery and supplies in, and to get the products of the country out. If there was a railway built I have no doubt it would get as good a revenue this fall from here as any point of the Canadian Pacific for sixty or seventy miles, and I think there would be a steady increase in the business. If the railway were built and the tariff done away with it would result in immense development, for the mining development of this country is only in its infancy. The mines in this region are the Beaver, the Badger, the Rabbit, the Carriboo, the Elgin, the Y1, the Peerless, the Silver Mountain east and west, the Porcupine, the Silver Fox, the Crown Point, the Little Pig, the Silver Creek, and the Big Harry. As far as I know I should say 75 per cent of the capital is American; the Beaver, Badger, Rabbit, Carriboo, Y1, Peerless, Silver Mountain west end, Silver Fox, Crown Point, Silver Creek and Big Harry are American; the Elgin, Porcupine, Little Pig and Big Bear are Canadian; and Silver Mountain east end is English. In the last four months the amount of sinking at the Beaver mine has been 138 feet, and of drifting and cross-cutting 471 feet. Drifting costs $4.70 per foot and sinking $13.50 per foot. The shaft is 8 by 14 feet and the drifts 5 by 7 feet, or the width of the vein. We pay miners $2 to $2.25 and laborers per day $1.50. The miners work by contract and board themselves; ten hours is a day's work. The hoisting engine 60 h. p. under 60 lb pressure, the compressor is 75 h. p., the stamp mill 200 h. p. and the saw-mill engine 25 h. p.; we have pony engines of 8 to 10 h. p. each; there is a pumping engine of 25 h. p., a Worthington of 40 h. p. and 2 Blake pumps of 12 h. p.. We have several other small pumps on the location, one being at the fire department. All the rest of the pumps would add about 40 h. p. more, and one in the stamp mill about fifty more. The stamp mill is a Gates. The rock goes through the rock breaker, which is Gate's patent, then through two batteries of five heads each of Fraser and Chalmers patent stamps, each head weighing about 850 lb. We have another battery of ten heads at Murillo ready to be brought and put up when the work requires it. That will make a capacity in running ore of about 50 tons a day. The ore goes from the stamp mill to the Frue vanners, of which there are four; it then runs into the mullers which are charged with quicksilver, then to the grinders, and finally into the creek. The character of the rock in which our vein occurs is slate, both the hanging and the foot walls; the slates are tilted on both sides, generally up. On the top of the slate there is trap, in some places as much as 40 or 50 feet. The vein is quartz, calc and heavy spar, iron pyrites and silver; the silver ore is pocketed. We have also zincblende, silver glance and argentine. There are several cross veins, one of them where we took out quite a little silver sometime ago. Generally, but not always, most of the silver is found where they join. The dip of the vein is from 5° to 18° from the perpendicular to the west. The course of the vein is nearly north and south, and the average width is about 2½ feet. We have not had a great deal of water, and I don't think they are much troubled with water in this district. The rocks are of close formation and the water only comes through the vein itself. We have one diamond drill here, and I think it is a very fine thing for such work as finding out which is the master vein in case of meeting with a horse, but I do not think it is any good to ascertain whether there is silver in a vein—that is, I do not think a vein should be condemned by a test made by a diamond drill. We can run a diamond drill for about 75 cents a foot, and in this slaty formation we can run a drill about 20 feet in 10 hours. It is very useful in examining iron deposits.

Product of the mine.

Need of a railway.

Mines in the district.

Cost of sinking and drilling.

Machinery.

Character of the vein.

Herbert Shear—I am superintendent of the Badger Mining Co. and have been three months in this district. The property consists of parts of locations 200 T and 201 T in Gillies, and have an area of 200 acres. I think that the company was organised in April, 1887, and a good deal of development work had been done before I came here; one drift was 450 feet and another 500 when I came. The capital stock of the company is $250,000 and is altogether held by Americans. The president is

Badger mine.

The company.

J. M. Stowell of Milwaukee, the secretary is Walter Reed, the treasurer C. Reed, both of Milwaukee, and the general manager is G. W. Robinson of Mobile, Alabama. The original discoverers sold five-eighths interest to Milwaukee parties for $20,000, and Mr. Robinson bought a one-fifth interest for $20,000; that is all the money that has been paid in to the present time. Up to the first of this month we have expended $18,900. We have made no shipments of ore yet, but we have about ten tons of smelting ore ready for shipment. It is very rich, but we have not had it assayed; it will run anyway 3,000 ounces to the ton—that is the selected ore. We have a dump of mill ore that we estimate at $200 to the ton, but no assays have been made. I do not think the mill ore all through will average more than $50 or $60 to the ton. We have a body of ore 300 feet long that could be stoped at the present time. The average width of the vein is about two feet. I estimate that there is about 1,300 tons that we can stope at the present time, and much of it is very rich. We employ 54 men, 32 being underground. The average wage is about $2 a day for underground miners and about $1.50 to $1.75 for surface hands. Our company intends to develop as fast as possible. We are now putting in a hoisting engine, and we have a stamp mill under construction. Our boilers were made in Peterborough and our engines in Milwaukee. Except engines and boilers, all machinery must be imported. Our hoisting engine will be 60 h. p. and the mill engine 100 h. p. In many instances failure has been due to putting up extensive works before the amount of ore mined would justify it. I would advise people before running into expense to wait till there is a sufficient show to justify it. To ship ore to Port Arthur would cost about $6.60 a ton for freight and hauling. If we had a railway I think it would cost about $1.60 a ton from the mill to Port Arthur. We intend to ship this week to Newark, New Jersey, and it will cost about $12.50 a ton all rail.

Working the mine.

Labor and wages.

Machinery.

Cost of freight.

Charles Hopkins—I have been mining in the lake Superior district for about thirteen years, exclusively at silver mining, and I have been captain of the Badger for seventeen months. The course of the Badger vein is north-west by south-east. The rock is slate, but there is about 30 feet of trap on the top. We are down about 63 feet in the slate. The vein is calcspar, fluorspar and quartz: quartz is next the foot and spar next the hanging wall. Sulphuret and native silver occur; there is some galena, blende, iron pyrites and black blende. The silver is chiefly in sulphurets; there is some native silver which is found in the trap mostly, very little in the slate. The silver is pretty evenly distributed throughout the vein. There are two adits; the upper one runs along the course of the vein 530 feet; there is 310 feet ready for stoping and it is a very promising exposure. All our underground mining is done by contract. Firewood does not cost much now—about 80 cents a cord and 50 cents for hauling, about $1.30 altogether; but the cost will increase as the wood has to be hauled a greater distance.

Character of the Badger vein.

Cost of fuel.

Henry Rothwell—I am connected with the Carriboo mine, which is situated on lot 3, 3rd concession of Paipoonge, to the east of Beaver Mountain mine, the location comprising 2,300 acres. There is about 800 feet drifted, and quite a little cross-cutting. There are two adits, but the work done so far is purely exploratory. The vein matter is 18 to 28 inches. We have not as yet taken out much ore, but simply samples, and we have not shipped any at all. I discovered three veins on the location, but as yet two of them have not been touched; their general direction is north and south. The gangue of our vein is about the same as the Beaver. I should call it a fissure vein; it has the best-defined foot wall in this district. The country rock is very badly broken, and we often find leaf silver as far as three feet outside of the vein. Native silver, zincblende and galena are found in the vein, which is spar mixed with slate, there being a great deal of slate in the vein matter. The dip of the vein is 20° to 25° west from the perpendicular. We worked from last November till the 16th of August with four miners, two surface men and a cook. The wages were—for miners $2 to $2.25, surface men $1.75, and the cook $35 a month. There was not a shot put in till we went to work. Two of the owners, Messrs. Barrington and Wilson, reside in Saginaw, and the other, Hiram Siley, in New York. So far we have spent about $6,000 in developing, but we have not got any machinery yet. I consider the indications extremely favorable. We stopped work this week, and cannot go on till there is a railway or some other way of getting into the country better than at present. I have been exploring here about twelve months, and I think this is going to be a permanent mineral country. I agree with Captain Hooper that the return for the investment has been very satisfactory. It is a misfortune that a great many claims are held by persons of limited means, who have not the capital to go on and develop the property they hold.

Carriboo location.

Character of the vein.

Rate of wages

Drawbacks to development.

W. N. Montgomery—Crown Point mine is location 95 R., consisting of 165 acres on the east side of Silver mountain. We began to develop the mine three years ago, and have driven two drifts, one about 128 and the other about 275 feet. I think they are both on the same vein, but there is no connection between them yet. The width of the vein where I struck it first in drifting is eight or ten inches, and a short distance from that it widened to 3½ feet and then narrowed down to 2 feet again. There have been several variations of the width of the vein. Two assays of the ore have been made, the result of one being 165 oz. to the ton. I took some out of the drift without picking which went $16.40 silver and $1.60 gold to the ton. The vein is in slate; sometimes the wall is clear and sometimes it is mixed. The distance between the drifts is 65 feet, but I think the ore is better in the lower than in the upper one. The upper drift is in the slate, above which is trap. We have both native silver and sulphurets. Crown Point mine.

T. H. Trethewey—I have been at East Silver Mountain mine since a year ago last October, and have been connected with mining operations since 1865. I worked formerly at Cape Mamainse. Our company, known as Silver Mountain mining company, was organised a year ago last October and commenced operations right away. Before this company acquired the property a Cleveland company worked it for some time. I think the stock of the company is $150,000, but I cannot tell you who the stockholders are; it is an English company. The property comprises locations R 53 and R 54, Lybster, and having an area of 1,158 acres. We have two levels, one of 700 feet and the other 1,400 feet. The 700 level is from 110 to 120 feet below the top of the mountain; the other is 74 feet below that, and from the bottom of one level to the bottom of the other is 81 feet. We have two shafts, one 110 feet deep and the other something over 400 feet. That work has been mainly done since I have been in charge. The Cleveland company had one drift of 160 feet, and that is included in the 700 feet level. There is also what we call No. 1 shaft, 80 feet. Our company has spent in labor and machinery about $86,000 or $90,000, and the Cleveland company spent about $20,000, making about $100,000 altogether. There has been shipped about four on five tons, which would average about $1,000 a ton. We have 1,200 to 1,500 tons on hand. Our mill rock runs from 10 to 18 oz. per ton, 10 oz. being the poorest. Assays of selected specimens have gone about $4,000 or $5,000 a ton. The width of the vein varies; at 400 feet down it is 12 feet wide, and there is some very good ore down there, but the best so far has been got near the surface. I cannot say how much ore we have in sight, as we have not yet developed enough; my idea is to develop till we have two years' stock of ore on the dump and two years' in sight; before that I do not propose to erect a stamp mill. We intend to ship our richest ores. I think we are going to have some very fine mines in this country. The developments so far have been very satisfactory. There is some gold in our ore, from $1 to $3 and $4 a ton, but it is only very occasionally that we test for gold. I do not think it would pay to treat our ores for gold. The course of the vein is about east and west. It does not outcrop through the trap. The mountain here is about 300 feet high. We have made six openings on the plain below, and traced the vein about 300 feet; it is there from four to six feet wide. The mill rock from the plain is about the same in character as from the mountain, and will pay about $14 a ton. The rock that bears the silver here is the same as that of the Beaver and Rabbit Mountain mines, and the gangue is also the same. It is chiefly calcspar, flourspar, heavy spar and quartz bearing iron pyrites, blende and silver. The silver occurs as native silver and silver glance. As we get down the best mineral-bearing rock is on the hanging wall. It is calcspar, flourspar, and heavy spar, but chiefly calcspar. The vein is richest where the width is from three inches to three feet. Our shaft is down about 400 feet, and that is about the junction of the slate with the cherty limestone on the hanging wall. The depth of the trap is about twenty feet, and I think the depth of the slate is about 300 feet. The vein is generally richer in the trap, but after reaching the cherty limestone we got a better average, the vein being more massive and more uniform in width. It is a true fissure vein; we have not got any cross veins as yet; we get a few little stringers occasionally; the vein matter at the junction of these little stringers is about the same; it is not particularly rich at the point of contact. We have 45 men working now, 24 of whom are working underground. We pay miners from $52 to $65 per month—$52 by the day and about $65 by contract, and to outside men we pay $45. For drifting by contract we pay from $5 to $14 a foot, the men paying for caps, fuse, powder and candles. Our drifts are six by seven feet. In the slate the drifting costs about $5, but where the vein is massive we pay about $14. We have not done any stoping yet. The

East Silver Mountain mine.

Development of the property.

Character of the vein.

Wages and machinery.

boiler and air compressor cost about $2,500; the hoisting engine and boilers, $3,000; four drills, $1,000; two pumps, $450; 3,000 feet of pipe, $1,000. Counting machinery and tools, all would come to about $10,000. We have two teams of horses, sleighs and waggons. The hoisting engine is 60-horse power, and the compressor about 20-horse power.

West Silver Mountain mine.

Henry H. Nicols—The property of West Silver Mountain mine is held by my brother, H. M. Nicols of Denver, and is composed of 55, 56, and 57 R in the township of Lybster, 240 acres. I came here about the 1st of June as manager. The shaft is down about 45 feet. I cannot say how much has been expended here. but we have not drifted any. The vein is well defined, and as exposed is 8 feet wide, but we have only tonched one wall. so it must be another foot anyway. The wall is slate but the cap of the mountain is trap. We took out about a ton and a half of what I consider very good ore from the excavation we were making for the shaft house. When I came here there had been a cross-cut of about 25 feet, and the shaft had been sunk about 25 feet. We have assays made of the ore which run all the way from 50 to 7,000 and 8,000 oz to the ton. I think the lowest assay I got was 27½ oz. There is silver glance, some native silver and a trace of gold; but there is no galena. In Colorado we have but very little trap, and the veins are blanket instead of fissure veins. All the high grade ore there carries more or less galena; particularly is that the case at Leadville, where nearly all the silver bands carry lead, which is useful as a flux in smelting. There is in Colorado one mine that paid a dividend of $30,000 a month for the last nine months before I left, and the richness varies very much there as here. We employ about 22 men here, and we are working another claim of 80 acres at the west end of Whitefish lake. At this place we employ 6 men, underground at $2.25 per day and outside laborers $1 75 to $2. On the other claim we have 12 men, but very little as been done there yet. We had to commence there in the woods, and have to pack back three and a half miles from the end of the lake; that is claim 264T; it is 14 miles from here. The vein looks very promising. There are two other claims further west in which they say they trace our vein. Most of the capital invested in this district is American I think.

Character of Colorada veins.

Rate of Wages.

Other locations.

Ambrose Cyrette—I have been in this country since 1862, and during that time I have paid a great deal of attention to minerals, and have explored the shore of lake Superior. I discovered the 3 A mine and got $7,000 for the property. The vein was 12 feet wide. There has not been any work done on it for some years, as there has been a lawsuit about it. If the matter were arranged and the mine worked, I think there would be a splendid return. It is 12 miles from here to the mine. I took up a location at Little Pic river and had assays made that showed as much as $218 of silver. There are a great many veins there, but no developement work has been done.

3 A mine.

Silver on Little Pic river.

John C. Haskins—I came to Port Arthur in 1872, and am familiar with the mining carried on in this country. We worked four men in 1872 and till the close of navigation in 1873. We found silver and gold and had assays made. The best ore was $13 to the ton in silver, and $7 in gold, and the deepest pit would not be more than 15 feet. The veins are in green slate and the main one is about 4 feet wide; there are three or four others. I am interested in Silver Hill and Silver Falls locations and have spent $6,000, all of which but about $800 was for development. I had to stop a little over a year ago on account of the want of capital. The trap there is about 50 feet deep. Work commenced in the trap and went down to the slate; we have just come to the slate now, but we had to abandon one shaft at 27 feet down on account of the water. The vein is a remarkably fine one, and is fully 13 feet wide where we struck it, just where four veins join. I think this is one of the finest mining regions in the world, and I have been working at mining since I was twelve years of age.

Silver Hill and Silver Falls locations.

William Murdoch—A rich vein has been opened by the Silver Islet company at Edward's island, from which arsenical silver was got. Large works have been erected there, but nothing is being done at present. The whole matter is at a standstill on account of legal and financial embarrassments.

Edward's island location.

Walpole Roland—I am interested as agent in a property known as the Silver Glance. It is on the west boundary of Strange, in the unsurveyed district. We have sunk 30 feet in one place and 15 feet in two other places, and the vein varies in width from 4½ to 6½ feet. The assays go from 50 to 20,000 oz. per ton. It is fully equal to anything we have in this country. An English company is prepared to put up $20,000 at once. There is a location to the south of that about three miles, near Wolverine lake, owned by the same parties. One pit as been sunk 30 feet, they are both in

the same kind of black slate. There are two veins upon this property, one running east and west and one north-east and south-west, the width in both cases being 4 feet, but opening up in places to eight feet. Assays show from 29 to 2,000 oz to the ton. West Silver Glance is the property of W. A. Allan of Ottawa, and consists of 19 and 20E and 238R. There is a strong lode on the property, assaying 511 oz. to the ton of black and native silver.

Locations in unsurveyed territory.

William Russell—We have a north-west and south-east system of silver veins to which the Beaver and Silver islet belong, and an east and west system to which the Silver Mountain mines belong. The Badger is the same as the Beaver, but the majority are east and west, or a little north of east. The thickness of the veins varies very much; one I am interested in is only nine inches in width, yet I think a great deal of it. It carries sulphuret of silver, native silver, zincblende and galena; the vein so far is quartz with a little spar. Assays vary very much in the same vein; I have had them where the result was almost nothing, and sometimes they would go as high as $3,000 or $4,000 to the ton; but there is not such great difference as that in the same vein as a rule. We have not got a steady low grade ore in this country. It occurs in bunches; we may find ore for over 100 feet that will pay well, and then we may find a long stretch of the vein that is worth nothing. The galena here is not as a rule argentiferous, being generally 87½ lead and 12½ sulphur. The galena from the Silver Islet vein will not go more than $3 per ton. In a few cases, as in the Beaver mine, we find the galena apparently rich in silver, but I do not think it is chemically associated with the silver; I think the silver occurs in the cleavages. Zincblende is sometimes rich in silver, as shown at the Porcupine and the Silver Hill mines (70R).

Systems of veins

Bunchy character of the ore.

James Millar—We have come across galena at Silver creek; the vein runs east and west and the surroundings are about the same as at the Victoria mine. We own two locations at Thessalon, near the dock; the vein runs east and west and carries galena; the gangue is calcspar and one can hardly tell it from Silver islet spar. The country rock is trap. This galena carries silver. An assay from the Silver creek vein shows $82 silver and a trace of gold; other assays show $38, $39, $48, and as low as $2.50. The vein is from twenty to twenty-four inches wide, principally slate. We sank two shafts on different veins, one 42 feet and the other 12 feet; there are five veins on the property close together. The vein matter is mainly chloritic slate and the walls granite. I have heard that lead has been found on the Goulais river, back from the front some 15 miles. The Indians bring specimens of iron pyrites, galena and copper pyrites, but I cannot say where from as they will not tell. The location on Thessalon river is on the Indian reserve, but I cannot tell the number of the lot; there are 84 acres on the main land, and we have a small island half a mile east of the river. The matrix is altogether spar, rather soft and of a pink color; I don't think there is any quartz. The vein is about 2½ feet wide on the surface, but we have only gone down three feet; the assays show silver $7.25 and gold $2.25. James Dobie is interested in this property with me and it is our intention to develop it. On lot 1 in the 5th concession of Drury, we found a silver-lead vein that runs $40 to the ton.

Silver in the Sault Ste. Marie district.

Silver creek location.

Thessalon river district.

Silver in Drury

R. E. Bailey—My company has a property on Garden river, west of the Victoria mine about four miles; it is silver-lead, and it shows as high as $90 a ton in the pure lead without taking the quartz with it. The vein runs north-west and south-east but is not regular; the country rock is trap, with some greenstone; it is of a different character from the Victoria mine. The vein matter is in places 20 feet wide, where the quartz is stratified with the rock.

Garden river location.

E. Norris—From what I have seen and learned I think lead and silver will pay the Sault Ste. Marie district. At Batchawana I have seen a great many really good specimens brought in by a man named Frank Vallequette, who has been exploring the district for the last ten or twelve years; but he has had a claim jumped once and will not tell where he got them. He showed me one specimen he got ten miles back from the lake that was really wonderful.

An explorer's specimens.

R. Hedley—I have seen some galena in the Sudbury district, but rarely, and I cannot say whether it exists in paying quantities. I had one sample of galena carrying 24 oz. of silver per ton, and the galena would run 60 per cent. lead. I have seen quartzose ores with a sprinkling of galena. One in Lorne township has diorite on one side and something between diorite and greenstone on the other; the vein is from fourteen to twenty inches wide. Another vein in the same township is in hornblendic schist on both sides. In Denison a vein has been traced a considerable distance which gives 4 dwt., and is in a micaceous slate.

Silver shows in the Sudbury district.

In lake Nipissing.

W. T. Newman—I found a silver vein on an island in the west end of lake Nipissing. The island is very small, about the size and shape of Silver islet; the vein is four to six feet wide and carries silver sulphuret. There is nothing else but granite on the island.

ZINC.

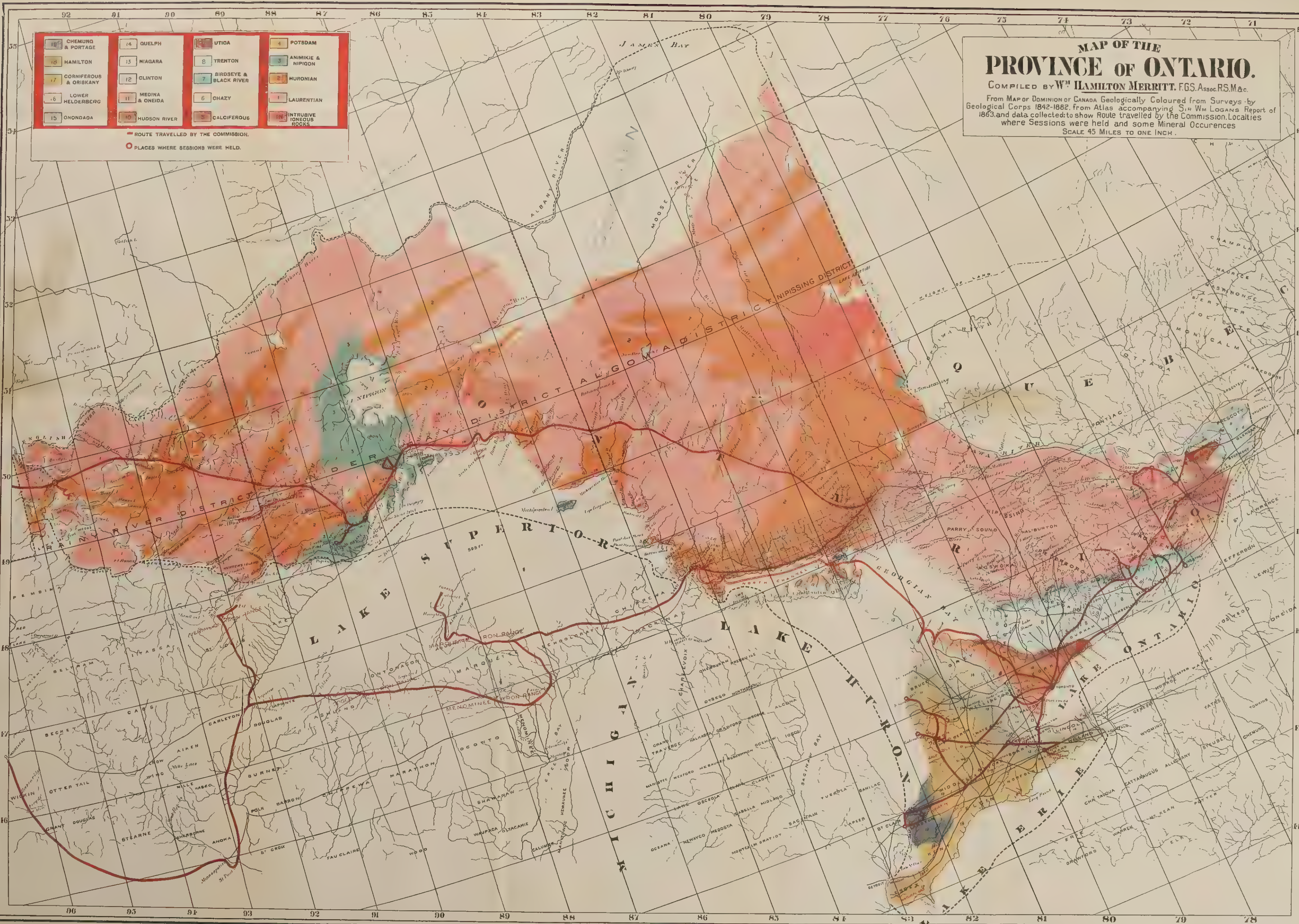
Its occurence in the Port Arthur district.

Zincblende occurs in nearly all the silver-carrying veins in the Port Arthur district, and, as already pointed out, usually holds silver. It is believed that the silver in this blende is altogether in a mechanical and not a chemical association with it. There is reported to be at least one large deposit of zincblende which it is believed could be worked profitably, but the Commissioners were not able to visit the place.

A COLLECTION OF MINERALS.

The peculiarity of the collection.

The Commissioners made it part of their duty to collect typical specimens of minerals, with accompanying rocks from the mines, mineral locations and works which they visited. As has been before stated lack of time made it impossible to make this collection as complete as might be desired, but it is believed that the accompanying wall rocks and country rocks, which were obtained wherever available, will make the collection as far as it goes of peculiar interest and value to mining men and scientists. Should the government entertain with favor the suggestion of a provincial museum, or collection of minerals, it would be advisable to take into consideration the importance of associating accompanying minerals, the wall rocks and the country rocks, with the various ores collected. This would add to the scientific value of the collection a practical utility which would commend itself at once to the mining man and prospector.


MAP OF THE
PROVINCE OF ONTARIO.
COMPILED BY Wm HAMILTON MERRITT. F.G.S. Assoc. R.S.M. &c.
From Map of Dominion of Canada Geologically Coloured from Surveys by Geological Corps 1842-1882, from Atlas accompanying Sir Wm Logans Report of 1863, and data collected: to show Route travelled by the Commission. Localties where Sessions were held and some Mineral Occurences
SCALE 45 MILES TO ONE INCH.
19 CHEMUNG & PORTAGE
18 HAMILTON
17 CORNIFEROUS & ORISKANY
16 LOWER HELDERBERG
15 ONONDAGA
14 GUELPH
13 NIAGARA
12 CLINTON
11 MEDINA & ONEIDA
10 HUDSON RIVER
9 UTICA
8 TRENTON
7 BIRDSEYE & BLACK RIVER
6 CHAZY
5 CALCIFEROUS
4 POTSDAM
3 ANIMIKIE & NIPIGON
2 HURONIAN
1 LAURENTIAN
IN INTRUSIVE IGNEOUS ROCKS
ROUTE TRAVELLED BY THE COMMISSION.
PLACES WHERE SESSIONS WERE HELD.
JAMES BAY
LAKE SUPERIOR
LAKE HURON
LAKE ONTARIO
LAKE ERIE
LAKE MICHIGAN
GEORGIAN BAY
NIPISSING DISTRICT
ALGOMA DISTRICT
THUNDER BAY DISTRICT
RAINY RIVER DISTRICT
QUEBEC
ONTARIO
PARRY SOUND
HALIBURTON
OTTAWA RIVER
PONTIAC
TORONTO LITHO. CO.

SECTION III.

INFLUENCE OF COMMERCIAL CONDITIONS UPON THE MINING INDUSTRY.

The mineral deposits of the province of Ontario are widely spread, varied in character, and cover almost the entire list of economic minerals with the exception of coal. The counties of Leeds, Lanark, Renfrew, Frontenac, Addington, Hastings, Peterborough, the districts of Nipissing and Algoma East and other portions of eastern and central Ontario contain numerous deposits of magnetic and hematite iron ores, and the discoveries now made over a wide area of country would seem to warrant the belief that as development proceeds the iron mines of this region will be found to be of great extent and value. It also appears that this region is rich in phosphates, gold, silver, copper, lead, plumbago, nickel, arsenic, mica and asbestos ; granite, marble and freestone in great variety and of excellent quality ; apatite, barytes and lithographic stone ; while even rubies, saphires and emeralds have been found. In the Sudbury region enormous deposits of copper and nickel ore have been discovered, and mines on an extensive scale are being developed. In the township of Denison, between Sudbury and lake Huron, rich specimens of gold-bearing quartz have been taken from the Vermilion and other mining locations, and promising deposits of copper and nickel have also been discovered. On the north shore of lake Huron, from Killarney to Sault Ste. Marie, and convenient to navigation, are found iron, copper, lead and immense quarries of marble. Northward of the Sudbury district prospectors report a mineral region of great extent and prospective value, but which can only be developed through the construction of a railway. The entire region north and west of lake Superior abounds in minerals and valuable quarries. Gold, silver, copper, iron, lead, nickel, plumbago and zinc are found ; agates and amethysts are abundant ; while valuable building stone of different kinds is spread over a large area. On Black bay is an immense quantity of granite of finer grain than the Aberdeen ; a red sandstone is found in great bodies at Nipigon bay, and a white sandstone at the head of Thunder bay which is of the finest quality. Brown sandstone of excellent quality is found in abundance, also soapstone, serpentine and marble of different colors. The Port Arthur silver district, extending south-west from Port Arthur to the east end of Arrow lake, promises to be an argentiferous region of great richness. Mines have been opened over a breadth of country extending twenty miles from north-east to south-west, and the range stretches some distance beyond the present limit of development. West of the silver range the Minnesota iron range, it is believed, projects into the territory of Ontario, and it seems certain

Extent and variety of the mineral resources of Ontario.

Eastern Ontario

The Sudbury and lake Huron district.

The Northern region.

The lake Superior country.

Building stones.

Port Arthur silver range.

An extensive iron range.

that an iron region of large area exists, embracing Hunter's island and the adjacent region. It is not improbable that this will prove to be one of the richest and most valuable iron producing districts within the province of Ontario. On the various islands in the Lake-of-the-Woods, and over an unknown extent of country around that lake, gold-bearing veins are numerous and seem to indicate from the result of assays of specimens and from the information obtained by partial exploration that this will become, when its mines are developed, one of the productive gold regions of America. But owing to the impossibility of obtaining titles while the dispute between the Dominion government and the government of Ontario was pending, none of the properties have been developed to any extent.

Lake-of-the-Woods gold region.

Imperfect knowledge of our unexplored territory.

Though prospecting has been carrried on to an extent which apparently justifies the conclusion that the mineral resources of Ontario are enormous, it must be confessed that the examinations are as yet incomplete and to a large degree superficial. Our territory is of vast extent. The proportion of the entire area settled and brought under cultivation is comparatively small. Great stretches of the country north of the height of land, where the formations warrant the expectation that minerals exist in great variety and quantity, have scarcely been touched by the foot of the white man, and where traversed at all it has been except in rare instances by the trapper and hunter, who would either be entirely ignorant of the nature and value of mineral indications or incapable of forming an intelligent opinion upon them. But enough is known to satisfy the careful observer that the vast region north of lakes Huron and Superior, once believed to be an inhospitable and worthless region of rock and muskeg, is possessed of an amount of mineral wealth likely to make it the most valuable portion of our great province. That region is also believed to have extensive valleys covered with heavy forests of hardwood, and possessing a soil and climate that will permit the growth of abundant and varied crops of grasses, grains, roots and vegetables. South-west of Port Arthur, in the promising silver range district, lies a region possessed of great scenic attractions, ridges of trap rock, wide valleys clothed with a heavy growth of poplar, birch and banksian pine, and having a deep fertile soil; while beautiful streams and charming lakes combine to give the region a just claim to unsurpassed picturesqueness and beauty. Productive farms and happy homes will in the near future reward the labors of the hardy settlers who are soon to occupy the wilds of the Whitefish valley and the regions beyond.

Regions of the Moose valley.

Richness of the Whitefish valley region.

Value of the disputed territory.

Of the mineral resources of the territory recently in dispute between the governments of the Dominion and Ontario, the title to which has been confirmed to the latter by the Judicial Committee of the Privy Council, enough is known to warrant the belief that the decision is one of very great moment to the province. The extension of the great Minnesota iron range into the territory of Canada is within the limits of the region in question. The mines of iron are likely to prove excellent in quality and practically limitless in quantity, and can be easily and cheaply brought to Port Arthur or other lake Superior ports by railways of easy grades and moderate length. The whole of the silver-bearing formation together with

the gold-bearing district around the Lake-of-the-Woods are also in this region, and it is far from improbable that the present undeveloped state of the country will give place in a few years to extensive mining operations, the employment of thousands of men, and a large annual addition to the world's stock of useful and precious metals. The disputed territory also has valuable areas of pine lands, and an extensive region of excellent agricultural land in the valley of the Rainy river.

MEANS OF DEVELOPMENT.

The government of Ontario has heretofore pursued a liberal and enlightened policy in promoting the construction of railway lines by grants of public money. By means of this aid many lines have been constructed in the newer sections of the province, some of which penetrate the mineral districts and furnish an outlet for ores and structural materials that would not otherwise be accessible. In addition to the ores and materials thus made available, the mineral deposits and quarries near the waters of the great lakes, conveniently situated for shipment, are numerous and abundant. Very few of the mines that have good facilities for shipment by rail or water are being worked to anything like their capacity of production. The magnificent quarries of granite, marble, red, white and brown sandstone, serpentine and soapstone situated at points along the lines of railways, and on the shores of Huron and Superior where the largest class of lake vessels can be loaded, are scarcely touched. Iron mines, from which it is believed millions of tons of ore might be shipped annually, are accessible or might be easily made so. Evidently the great want is something else than means of transportation, and some enquiry will be made later on as to the cause or causes of the prevailing stagnation.

Means of development.

Just at present there exists a pressing necessity for a short railway line from Port Arthur to the silver range district south-west of that place. No doubt is entertained as to the extent or great value of the silver lodes of that section. Experienced miners believe that it will prove the richest silver region in America. The mines now opened are contending with great difficulties, arising from the expense and delay attendant upon teaming supplies and minerals over a colonisation road never good, and at times nearly impassable. A short railway line would give a wonderful impetus to the development of the valuable mines now opened, and would undoubtedly lead to the opening of many new ones and to the inauguration of a period of great activity and prosperity. The road should be built to Whitefish lake, a distance of about 45 miles, as speedily as possible, and should then be extended from that point westward into the iron range, so as to effect a junction with the Minnesota iron range road. The Dominion government has voted a bonus of $3,200 per mile for the portion of the road from Port Arthur to Gunflint lake, a distance of 85 miles, and the grant for the shorter link by the government of Ontario will doubtless ensure the construction of the line to the vicinity of Whitefish lake. With this section of the road completed the most pressing want of the mineral district will be met, temporarily at least, and it is probable that the company can then command the resources necessary to secure the extension of its line westward.

Claims of the Port Arthur silver range.

A mining region of great promise.

That the region of the Whitefish valley is one of great promise cannot be doubted. The testimony of mining experts from Colorado and other silver producing regions is unanimous upon that point. Actual development has gone so far as to remove the question from the region of speculation. The Beaver mine was opened three years ago. The total amount of money expended up to August 1, 1888, exclusive of cost of land, was $169,288. This included an expensive plant, consisting in part of hoisting machinery and a large stamp mill. The amount of silver taken from the mine up to August 20, 1888, was 383,630 ounces, valued at $368,285. There was besides at that date a great amount of ore uncovered and ready to remove. Many other mines have been so far developed, too, as to render it certain that they will yield highly satisfactory returns.

Extensive iron deposits.

The iron district is also likely to prove of immense importance. Indications warrant the belief that the iron deposits in Minnesota are less extensive than those upon the same range within the province of Ontario. The Minnesota mines have but recently been made accessible by a railway line from Two Harbors on lake Superior, yet shipments from these mines for the last five years show a record strikingly suggestive of a rapidly expanding business. Following are the figures:

	1884.	1885.	1886.	1887.	1888.
Long tons........	62,124	225,484	304,396	390,467	450,475

With a railway line in operation from Port Arthur westward and south-westward, iron ore can be laid down at Port Arthur for shipment practically at the same cost for railway freight as at Two Harbors. It may not be necessary to push the line beyond the silver district merely for the purpose of securing mineral development while the American duties on iron ore continue, but if reciprocity ever becomes an accomplished fact a railway line from Port Arthur to the iron range could not fail to be the means of developing an enormous business in the mining, transportation and shipping of iron ore.

With the exception of this line, and one to secure competitive rates for the Sudbury district, there does not seem to be an urgent necessity at the present time for the construction of railways to aid in mineral development. But with a further and greatly increased development of our mineral resources extension of old lines and construction of new ones will doubtless become necessary, and sections now but imperfectly known, such as the country between the height of land north of lake Nipissing and James bay, will then be able to present strong claims for aid.

MINING CAPITAL AND MANAGEMENT.

Canadian, English and American capital invested in mining operations.

The investigations of the Commission lead to the conclusion that more than one-half of the capital invested in mining operations in Ontario is American, and that the amount of Canadian capital invested exceeds the amount of English capital. The evidence also leads to the conclusion that the American investments are managed as a rule by experienced and trained men, who are capable of giving intelligent direction to the operations under their charge. It is quite evident in most cases that practical education of a thorough character has been acquired by these American mine captains in connection with the prosecution of mining enterprises in the United States,

and many of them have also received the advantages of technical education in American mining schools. Canadian prospectors and miners are found as a rule to possess intelligence and energy, but in many cases they have lacked opportunity to obtain either practical or technical education. It is evident that a Canadian school of mines would do good service, and the advantages to be derived from such an institution will be more fully dwelt upon hereafter. Complaints in many instances are made that English companies have sent out managers who knew little about their business or the requirements of the country and who consequently spent money with very little advantage to their employers, and that in consequence of incompetent management failure resulted and discredit has been brought upon Canadian mining investments in the estimation of English capitalists.

VALUE OF MINERAL PRODUCTS.

Reliable statistics as to the value of the annual mineral products of Canada or of Ontario are not obtainable except for a limited period, and it would be too much to claim strict accuracy for some of the tables given. Almost the only reports upon the production and value of minerals in Canada, aside from the census returns of 1871 and 1881, are the statistical reports of the mining engineer to the Geological Survey, to whose reports for 1886 and 1887 the Commission is indebted for information regarding Canadian mineral production. The census returns of 1871 and 1881 give the quantities of raw minerals produced in Canada for the years 1870 and 1880 respectively, but they fail to furnish information as to values. From these sources a comparison of the mineral production of Canada for the years 1870, 1880 and 1887 may be made as to quantities, as also a comparison of the mineral production of Ontario for the same years, those for 1887 being taken from the Geological Survey report as far as returns are given.

Statistics of production.

MINERAL PRODUCTION OF CANADA IN THE YEARS 1870, 1880 AND 1887.

Minerals.	1870.	1880.	1887.	
	Quantity.	Quantity.	Quantity.	Value.
Gold ....oz.	22,941	70,015	66,270	$1,178,637
Silver .... "	69,197	87,024	....	349,330
Copper ore ....tons.	13,310	8,177	40,800	342,340
Iron ore .... "	129,363	223,057	76,330	146,197
Pyrites .... "	2,800	20,770	38,043	171,194
Manganese .... "	635	2,449	1,245	43,658
Coal .... "	671,008	1,307,824	2,368,891	4,758,590
Plumbago .... "	270	28	....	....
Gypsum, lump .... "	114,433	183,076	154,008	157,277
Phosphate of lime ...... "	1,980	14,747	23,690	319,815
Mica...................lb.	4,010	16,076	22,083	29,816
Petroleum, crude.......gallons.	12,969,435	15,490,622	26,737,655	595,868
Stone for dressing.......cubic feet.	5,206,796	8,141,227	7,089,984	552,267
Granite.................tons.	....	....	21,217	142,506
Grained marble ....cubic feet.	8,870	40,126	....	....
Grained marble ....tons.	....	....	242	6,224
Salt ....barrels.	....	472,074	429,807	166,394

MINERAL PRODUCTION OF ONTARIO IN THE YEARS 1870, 1880 AND 1887.

Minerals.		1870.	1880.	1887.
Gold	oz.	199	152	450
Silver	"	69,197	87,000	190,495
Copper ore	tons.	1,934	170	567
Iron ore	"	30,726	91,877	16,598
Pyrites	"	500	1,180	....
Gypsum	"	4,230	5,000	8,560
Phosphate of lime	"	1,975	5,658	4,101
Mica	lb.	....	200	....
Crude petroleum	gals.	12,969,435	15,490,622	26,737,655
Salt	bbl.	....	472,000	429,807
Grained marble	cubic feet.	8,870	5,000	....
Stone for dressing	"	2,093,711	3,698,488	4,979,502
Roofing slate	squares.	....	1,536	....
Arsenic	lb.	....	....	13,136

Petroleum and salt.

Ontario is the only province of the Dominion which produces petroleum and salt; and while we could not perhaps hope to compete with American manufacturers of illuminating oil, there does not seem to be much doubt of our ability to hold the home market for machinery oils, as Petrolia refiners are now finding a market for this class of oils in the United States. The salt fields of Ontario have an area of about 1,200 square miles, and reports upon the quality of the salt made by American and Canadian experts show that it is of exceptional purity. But although a superior article is produced and the wells could easily treble their present output, the industry has made no progress during the present decade owing to want of a sufficient market, while the selling price is lower than what is obtained at the wells in the neighboring state of Michigan.

Production of iron ore and pig iron.

In 1887 the amount of iron ore used in the production of pig iron was estimated at 60,434 tons, and is included in the total product for that year of 76,330 tons as given in the table of products for the Dominion. The Geological Survey report gives the export of iron ore from Canada for the calendar year 1887 at 13,692 tons, of which 12,224 tons was from Ontario. The trade returns give the export from Canada for the fiscal year 1887 at 23,387 tons, of which 18,907 tons was from Ontario. Copper, iron and pig iron are not classed in the census returns as raw mineral products, and these are not included in the above tables of comparative production. The production of pig iron for 1887 is estimated at 24,827 tons. The returns of all kinds of iron, exclusive of pig, produced in the Dominion in that year give the amount as 31,527 tons, and of steel as 7,326 tons. The returns, however, are incomplete, and the amount of iron produced is supposed to be one-third greater than the figure given. The material used in manufacture was chiefly scrap iron and scrap steel.

Ontario's mineral exports.

The following table gives the exports of the products of the mine from Ontario to Great Britain, the United States and other countries since 1869, the first year when statistics of exports were given seperately for the Province :

EXPORTS FROM ONTARIO BY COUNTRIES.

Year.	Great Britain.	United States.	Other countries.	Total value.
1869	$203,435	$236,068	....	$439,503
1870	465,701	765,112	....	1,230,813
1871	415,782	1,578,252	....	1,994,034
1872	440,355	2,555,935	....	2,996,290
1873	782,114	3,221,590	....	4,003,704
1874	188,064	947,354	....	1,135,418
1875	....	879,017	....	879,017
1876	....	745,362	....	745,362
1877	756,867	267,565	....	1,024,432
1878	4,675	185,874	....	190,549
1879	79,711	746,027	$21	825,759
1880	758	316,468	....	317,226
1881	....	237,869	....	237,869
1882	5	239,996	....	240,001
1883	....	208,489	....	208,489
1884	20	140,849	....	140,869
1885	235	239,310	....	239,545
1886	2,000	168,638	2,556	173,194
1887	270	172,284	....	172,554
1888	325	477,271	....	477,596
Total	$3,340,317	$14,329,330	$2,577	$17,672,224

A classification by minerals for the same period of twenty years shows the quantity and value of exports from the province to be as follows :

EXPORTS FROM ONTARIO IN TWENTY YEARS BY MINERALS.

Product.		Quantity.	Value.
Gold bearing quartz		....	$9,943
Oils—mineral, coal and kerosene	gal.	35,409,141	6,421,347
Gypsum	tons.	6,719	10,254
Copper	"	158	553
Copper ore	"	5,824	155,417
Iron ore	"	524,511	1,314,357
Pig and scrap iron	"	180,148	2,348,017
Silver ore	"	....	5,894,564
Mica	lb.	6,506	6,884
Lead ore	tons.	1	100
Plumbago		....	6,090
Antimony ore	tons.	2	3,000
Stone and marble		....	407,309
Sand and gravel	tons.	765,670	150,820
Salt	"	5,086,980	484,668
Phosphates	"	10,272	125,411
Other articles		....	333,490
Total		....	$17,672,224

As shown by the former table, the share of those exports to the United States in the twenty years was $14,329,330, while Great Britain's share was $3,340,317, and all other countries only $2,577.

Table I of mineral production of the Dominion appended to this Section of the report gives the value for 1886 at $10,529,361 and for 1887 at $15,000,000, but the seemingly large increase of $4,470,639 will appear as an actual increase of only $1,247,936 when the articles which are given in the return for 1887 but not in 1886 are taken into account, and the quantity and value of each struck out in making a comparative statement.*

COMPARISON WITH UNITED STATES PRODUCTS.

Mineral products of Canada and the United States.

If we compare our own volume of mineral production with that of the United States the result will be the discovery that the development of the mineral resources of Canada is in the main in a backward condition as compared with the mineral development of that country. The extent of this disparity will naturally precede enquiry into its causes, and will possibly sharpen the desire to discover a remedy for the existing condition of the Canadian mineral industry.

Elements of a fair comparison.

In making the comparison of production between the two countries it will be necessary to strike certain items from the summary of production of Canada for 1887, as given in Table I, in order to make the list of articles classed as metallic and mineral products correspond with the United States classification. In that country pig iron is classed as a mineral product; iron ore is not embraced in the classification, as in that case the value of the pig iron would include the duplication of the value of the ore used in its production. For the same reason iron and steel are not included in the classification, as these articles are the manufactured product of pig iron. To give their value would be to duplicate the value of the pig iron used in their production, and adding thereto the cost of converting a raw material into a manufactured article and the profit of conversion. Coke is an article manufactured from coal, and is not classed as a mineral product in the United States. Neither are brick and tile classed as mineral productions. If we strike from our list of minerals for 1887 the following articles and values, our summary of production for that year will very closely correspond in classification and character to the summary of mineral production in the United States for the same year, as given in the volume of Mineral Resources published by the Geological Survey.

ARTICLES ELIMINATED FROM THE CANADIAN TABLE.

Mineral or product.		Quantity.	Value.
Brick	m	181,581	$986,689
Coke	tons.	40,428	135,951
Iron	"	31,527	1,087,728
Iron ore used in manufacture of pig iron	"	60,434	114,390
Steel	"	7,326	331,199
Tile	m.	14,658	230,068
Total			$2,886,025

* Statistics of production in Ontario for the year 1888, collected by the Commission, are given in Section II of this report, p. 72.

This amount of $2,886,025 deducted from the total of $15,000,000, given in the Geological Survey report for 1887, leaves the actual production for that year as $12,113,975, based upon the American rule of classification. But it is a question whether this amount ought not to be further reduced by a round million at least, if not by the whole sum of $1,610,499 given in the table as the "estimated value of mineral products not returned." This estimate, or more properly perhaps, this guess, seems a loose and somewhat exaggerated calculation. No estimate of a like kind appears in the United States returns, the only thing in any way corresponding with it being "estimated value of mineral products unspecified, $6,000,000." It is permitted to stand as an actual item in Canadian mineral production for 1887, but in doing so it is proper to say that the comparison between the mineral production of the United States and Canada which follows is more unfavorable to the latter country, in all probability, than the actual facts would warrant. Canadian product.

For the year 1887 the mineral production of the United States, according to the report of Mr. Day, chief of the Mining Statistics division of the Geological Survey, amounted to $542,284,225, or more than forty-fold greater than the production of Canada. Estimating the population of Canada at one-twelfth that of the United States, the ratio of production per head was as $2.40 for Canada to $9 for the United States. With the enormous mineral resources possessed by the Dominion it cannot be considered a satisfactory condition of our mining development when the nation to the south of us shows mineral output nearly four times greater per capita than our own. An examination of the details of production may be of service for the purpose of comparison as far as relates to minerals of which we have an abundant supply, and it is here given. United States product.

COMPARATIVE PRODUCTION OF CANADA AND THE UNITED STATES.

Mineral or Product.		Canadian production.	United States production.	Ratio of production per capita in	
				C.	U. S.
Iron ore	long tons.	68,151*	11,300,000	1	13.82
Pig iron	"	22,167*	6,417,148	1	24.12
Copper	pounds.	3,260,424	184,670,524	1	4.70
Lead	short tons.	102	160,700	1	131.00
Coal, bituminous and anthracite	long tons.	2,115,080*	116,049,604	1	4.57
Coke	short tons.	40,428	7,857,487	1	16.20
Phosphate	long tons.	21,152*	480,558	1	1.90
Building stone	dollars.	552,267	25,000,000	1	3.77
Gold	"	1,178,637	33,100,000	1	1.58
Silver	"	349,330	53,441,300	1	12.74
Brick and tile	"	1,216,757	47,000,000	1	3.15
Lime	bushels.	2,269,087	116,875,000	1	4.29
Cement	barrels.	69,843	6,692,744	1	8.00

* The short ton of 2,000 lb., used in the table of Canadian production in Table I appended to this Section, has here been converted into the long ton of 2,240 lb.

Exports of minerals from Ontario.

The following table, giving a summary of the value of minerals exported by Ontario for the calendar years 1874 to 1886 and by the Dominion for the years 1874 to 1887, shows that the mineral export trade of the province is of small proportions, and is relatively small even as compared with the exports of the Dominion. The largest items are gold and coal, amounting in 1886 to $2,627,024 and in 1887 to $2,616,112, neither of which figure in the exports from Ontario for those years except for a trifling amount.

VALUE OF MINERAL EXPORTS FROM ONTARIO AND CANADA.

Calendar Year.	Ontario.	Dominion, including Ontario.
	$	$
1874	955,820	3,977,216
1875	657,926	3,878,050
1876	949,645	3,731,827
1877	137,308	3,644,040
1878	828,669	2,816,347
1879	287,109	3,082,900
1880	280,488	2,877,351
1881	243,598	2,767,829
1882	245,195	3,013,573
1883	128,935	2,970,886
1884	239,323	3,247,092
1885	185,529	3,639,537
1886	186,574	3,951,147
1887	....	3,805,959

The United States our principal customer for products of the mine.

Table II appended to this Section gives the mineral exports of the Dominion to the United States, Great Britain and all other countries by quantities and values for the seven fiscal years 1881 to 1887. From this table it will be seen that the United States is our principal customer for the products of our mines, having in the period of seven years covered by the table taken $18,567,710, or almost 80 per cent. of the whole, while during the same period all the rest of the world took only $4,828,313. This result is the more remarkable when it is considered that during the entire period our export trade with the United States was burdened with impost duties upon the more important of our minerals, such as coal, copper ore, iron ore and building stone. The effect of these duties was to seriously curtail the movement of nearly all articles on the list of our mineral exports, and very nearly to prohibit transactions in many of them, in which but for the duties the business could not have failed to assume enormous proportions. It will be interesting to enquire, as will be done later on, what would be the probable effect produced by the removal of these duties. It will be interesting especially to enquire what the effect would be upon Ontario, whose vast deposits of copper ore in the Sudbury district and elsewhere are within easy distance of the furnaces of the United States, whose apparently limitless supply of iron ore in eastern Ontario can be transported to the furnaces of Cleveland and Pittsburg as cheaply as the ores of the lake Superior district, and whose

mountains of marble, granite and sandstone, situated directly upon the navigable waters of lake Huron and lake Superior and within short distances by rail of lake Ontario, can be laid down in quantities equal to any possible demand,—in quality superior to any material of like character obtainable on American territory within the basin of the great lakes, and at prices which but for the duties might defy competition at such commercial centres as Chicago, Milwaukee, Detroit, Cleveland and Buffalo, and that would secure enormous sales in Boston, New York, Philadelphia and other eastern cities. Doubtless conjectures as to the increase of Ontario's export trade in mineral products under the condition of removal of the American duties are to a certain degree speculative; but when the question is examined it will be apparent that the increase could not fail to be very large, and one more likely to exceed than to fall short of expectations based upon the best attainable data.

POSSIBILITY OF LARGER PRODUCTION UNDER PRESENT CONDITIONS.

Few if any of the mining industries of Ontario and Canada, with their allied manufacturing interests, have reached that extent of development which seems not only possible but easy of attainment. In other pursuits, such as farming, fishing, lumbering and manufacturing in various lines, a large measure of success has been achieved, and therefore it cannot be alleged that failure to utilise the mineral resources of the country is due to a natural lack of energy or enterprise in our people. Progress has been hindered by a variety of causes, some of which will be indicated; but there is reason to believe that in some directions, and under existing conditions, skill and capital ought to give promising results.

The iron industry.

CHARCOAL AND COKE IRON.

What has just been said appears to apply in a special sense to the iron industry. The Canadian market is a limited one, it is true, and development upon a large scale if confined to the supply of our own wants cannot be expected. With the present duties upon iron, however, and the additional protection afforded by the bonus upon Canadian pig iron, the production of iron and its manufactured products of wrought and malleable iron and steel ought to be largely increased. Our importation of pig iron for the fiscal year 1887 amounted to 50,000 tons; our production for the calendar year was 24,827 tons. We exported none, and our consumption was in round numbers 75,000 tons. Of this amount 10,000 tons was imported from the United States, consisting entirely of charcoal and other special grades of iron. Considerable space will be devoted later on to the question of the production of charcoal iron. There seems to be no reason why this article cannot be as cheaply produced in Ontario as in the United States, and the entire amount now imported for domestic consumption ought to be speedily added to the sum of our iron production. Further than this, charcoal iron, owing to its greater strength and superior qualities, could in all probability be supplied after furnaces were in operation at prices that would secure its use for many purposes where Scotch and English pig iron is now used. Intelligent iron founders testify that they would use it to a large extent if it could be obtained at a price moderately in excess of the price of ordinary

Charcoal iron.

iron. For all strong castings it is thought that it would command the market at about $2 to $4 per ton more than coke iron at the present range of prices.

Coke iron.

As to the production of coke iron, Ontario's distance from coal fields places her at some disadvantage, though the transportation of coke to the ore bed may cost no more than the transportation of the ore to the coal bed; and with the protection now enjoyed it can probably be shown that coke iron may be manufactured in Ontario at present prices with a small profit, if well appointed furnaces were erected and the duty upon coke removed. In Nova Scotia the conditions for producing iron cheaply are so favorable that the furnaces of that province ought to be able, with the present degree of protection and encouragement, to undersell the iron masters of Scotland and England and supply the bulk of the coke iron used in the Dominion, assuming that they can produce iron of satisfactory quality. Adequate capital, furnaces with the modern improvements, together with energy and intelligent supervision in the prosecution of operations and processes would be quite sufficient, judging from such data and information as are attainable, to produce the desired results.

Annual consumption of iron in Canada.

Not only is it reasonable to suppose that with the present protection afforded by duties and bonus, amounting together to $5.50 per net ton, we should be able to supply almost our entire consumption of charcoal and coke pig iron, but there seems to exist no good reason why a considerable part, if not the greater part, of the iron and steel now imported and subject to the payment of duty should not be manufactured in Canada from pig iron produced in this country. The tariff upon manufactures of iron and steel is in the main protective in its character, and should secure the manufacture in Canada of much of the iron and steel now imported. The equivalent in pig iron of iron and steel entered for consumption in 1887, without including cutlery, instruments, tools, machinery and engines, amounted to at least 275,000 short tons. If we could supply ourselves with iron and steel equivalent to 175,000 tons of this amount, and also supply the present consumption of 75,000 tons of imported and domestic pig iron, it would not be in excess of a reasonable development of our iron industries under present conditions. The production of 250,000 short tons of pig iron, equally divided between charcoal and coke iron, would require at least eight days' labor for each ton of charcoal iron, and six and a half days' labor for each ton of coke iron, or a total of 1,800,000 days' labor in mining coal, making coke and charcoal, mining ore, quarrying limestone for flux and smelting the ore. This amount of labor would not include the transportation and handling of material, the erection of works, construction of machinery, and many other items which are contingent upon the manufacture of pig iron. A large additional amount of labor would be employed in converting pig iron into iron and steel. About 500,000 tons of ore would be used, about 450,000 tons of coke and charcoal would be required for the smelting of the ore, besides a large amount of coal for iron and steel manufacture. The value of 250,000 short tons of coke and charcoal iron would be at least $5,000,000 at the point of production in Canada, coming within the cost of importing an article equal in quality and value to an extent sufficient to command the market.

What its production represents in labor.

If this stage of development of the iron industries of Canada were reached, Ontario should supply at least three-fifths of the entire product of charcoal iron and a considerable percentage of the coke iron, and it is not unreasonable to estimate that at least 200,000 tons of Ontario ore would be used in producing iron for the supply of the home demand. That Canada can hope to reach under present conditions a production of a larger proportion of her consumption of iron and steel than above indicated is hardly to be expected, and owing to the disadvantages as compared with Nova Scotia under which Ontario labors regarding a supply of coal and coke, we can scarcely claim for our own province that we can supply more than two-fifths of the entire quantity of iron likely to be produced in the Dominion.

Limits of production in Ontario.

GOLD, SILVER AND COPPER PRODUCTION.

Under the existing condition of matters the production of these metals is retarded by duties upon machinery and supplies, and by want of transportation facilities. In Ontario the discovery of rich mines of these metals is of comparatively recent date. In the case of gold and silver ores, or bullion, no trade restrictions interfere with their exportation to any country with which we trade. In the case of copper, smelting works on a large scale are being established at Sudbury. Great advantage would be secured to the copper interest if the American duty on the ore was removed, as profitable operations in the export trade could in that case be prosecuted at many mines where lack of capital prevents the erection of extensive works, or where the extent of ore supply does not warrant the expenditure.

Causes which retard development.

PRODUCTION OF SALT.

The salt interest complains of the free admission of English salt for other purposes than those of the fisherman's use. It is shipped at a nominal cost for freight, being generally brought by vessels as ballast. The duty upon fuel is also a great drawback. Coal slack, costing a few cents only per ton at the mine, pays a duty several times in excess of its first cost. The removal of this duty, it is claimed, would afford great relief to the salt-producing industry of Ontario. Free admission to the United States would secure a wide market and would, with free coal, put the business upon a paying basis and render a great increase of salt production certain.

Effect of free salt and dutiable fuel on the industry.

MARBLE AND BUILDING STONE.

Our export of stone and marble unwrought is insignificant in amount, its value for the entire Dominion being only $65,601 in 1887. We can supply our own demand, but although we have an unlimited amount of the finest marble, granite and sandstone in great variety of color and of unusual excellence as regards strength, powers of resistance to fire and frost, and susceptibility to high polish, yet under existing circumstances we cannot hope to increase our export trade to any considerable extent. From the magnificent and widely spread quarries of Ontario the cities of the upper St. Lawrence basin and the seaboard cities of the middle states could draw their supplies of the finer qualities of sandstone, granite and variegated marbles with the greatest economy of cost, but for the American duties. These effectually shut us out from a demand for our structural materials that could not fail to reach great proportions if trade between the two countries was entirely untrammelled.

An abundant supply, but a circumscribed market.

SOME THINGS THE DOMINION GOVERNMENT MIGHT DO.

Industries hampered by customs duties.

In looking over the ground to discover by what means the mineral interests of the country could be promoted and mineral development increased, it is readily seen that the Dominion government could afford great aid to struggling and infant mineral industries, not so much in the great majority of cases by imposing taxes upon the general public for their benefit, as by removing taxes that are a serious and in some cases a ruinous burden to them.

Pig iron.

To the individual contemplating the investment of money in plant for producing pig iron the government would afford great encouragement by an offer to admit coal and coke used in the production of iron and fire brick and machinery not obtainable in Canada free of duty.

Salt.

To the manufacturer of salt the admission of coal slack for fuel free of duty would be a great boon.

Silver, copper and gold.

To the silver, copper and gold mining companies the admission of the improved machinery for hoisting works and stamp mills not yet manufactured in Canada, and the admission of coal when required for smelting and fuel for engines driving machinery, would afford material relief and greatly aid in the development of mining properties and in increasing mineral production.

Facilities for entering articles liable to duty.

An important concession to all parties engaged in mining and being under the necessity of importing machinery and supplies, and making entries at a Canadian customs house, would be to give prompt and courteous consideration and fair treatment in all such cases. Many complaints are made as to undue suspicion of under-valuation, and as to vexatious delays from various other causes. Rigid adherence to the Customs act is said to lead in some cases to arbitrary valuation of machinery at figures much above its actual cost. At one important mining centre in the interior of Ontario the delays in getting machinery passed at the frontier were so great that the mining company offered to pay the salary of a sub-collector if an office were opened at the point where they were doing business. Unreasonable complaints may be and no doubt often are made, but liberality of spirit and anxiety to treat with the utmost fairness and courtesy important interests and business enterprises of great value to the country should ever be a characteristic of the officials of the Canadian customs.

INTER-CONTINENTAL AND INTER-PROVINCIAL TRADE.

A strong feeling in favor of gaining free access to the United States markets.

An honest and in any degree a complete report upon the mineral resources of Ontario and the best means for developing them must of necessity give a considerable degree of prominence to the question of inter-continental trade. At every point the Commission met with evidences of the great importance of securing wider markets. Everywhere the witnesses examined either felt impelled to allude to the importance of this matter of securing access to other markets, or fully admitted its importance when allusion was made to the subject. Differences of opinion upon the questions of establishing mining schools, granting bonuses to promote iron production, changes in the mining laws, everything else in fact, were in all cases developed; but upon the question of the desirability of obtaining free access to the American markets for our mineral productions there existed absolutely no difference of opinion so far as we could judge among men interested in mining enterprises, except in the case of those interested in petroleum, and in one solitary instance in

the case of a producer of salt. With the consciousness on the part of the intelligent men interested in mines whom we met from Ottawa to Rat Portage, that with boundless mineral resources and a market the limits of which were exceedingly narrow, we were cribbed and dwarfed in our attempts to make developments, the cry everywhere was "Give us the American markets; break down the barriers that separate us from 60,000,000 customers at our very door!" Whether this desire may possess the farmer, the lumberman and the fisherman or not, it certainly awakens the earnest longings of the mining population of Ontario.

GEOGRAPHICAL CONDITIONS.

The fact that Canada and the United States are geographically one great country—with a conterminous boundary line from ocean to ocean, naturally drawn to each other by the provisions and requirements of nature, having common interests that compel intercourse except in case of actual war, having populations of the same race and language, each country finding it impossible to ignore the existence of the other, and each enforcing restrictions upon trade with the other at the cost of great inconvenience and loss—is a fact that stands out in as bold relief as does the opposite fact that the two countries in their political autonomy are separate and distinct. The natural intimacy of association and connection existing between some portions of the American Union is not as great as that existing between Ontario and Quebec and the eastern, middle and western states, or between the maritime provinces and the states upon the Atlantic seaboard, or between Manitoba and the northwest and the states of the upper Mississippi valley, or between British Columbia and the states of the Pacific slope. A considerable portion of the boundary which separates the two countries is a grand waterway comprising great stretches of mighty rivers and four great inland seas. These lakes and rivers invite commercial inter-communication, and serve to link together in the bonds of common interest the two countries rather than to separate them. Upon their waters the commercial marine of both countries is actively employed in transporting the products of each country to the marts of the other, or in conveying the productions of the fruitful west to the seaboard states and provinces. For the improvement of this great natural highway each country has spent enormous sums, and the vessels of either country may pass from Duluth or Chicago to the sea without hindrance, but indebted to the public works constructed by both for the ability to do so. Great as is the magnitude of the commerce that floats upon this imperial highway of rivers and seas, it is but the advance wave of the mighty tide that shall come when the agricultural and mineral resources of the great countries naturally tributary to these waters are fully developed and the shackles upon trade between kindred states and provinces are removed.

The two countries are geographically one.

Conditions favoring commercial intercourse.

The energetic zone of North America may be said to lie between the 38th and the 48th parallels of latitude. In the galaxy of Anglo-Saxon commonwealths within this zone not one occupies a more commanding commercial position than does the great province of Ontario. With reference to commercial interchanges between the east and the west, neither hostile tariffs, separate nationality, nor commercial belligerency have been found sufficient

The energetic zone of the continent,

and Ontario's place in it.

to deprive this province of many of the commercial advantages to which nature has declared it to be the heir. The Ontario peninsula is projected like a wedge into the territory of the United States, and across it lies the short cut of travel and traffic between Michigan and the east, between Chicago and New York, and between the north-western and the eastern states. By the lines south of lake Superior and eastward from Sault Ste. Marie through the territory of Ontario, northern Michigan, northern Wisconsin, Minnesota, Dakota and Montana will find their shortest and cheapest route to the seaboard. The agricultural portion of Ontario is nearer to the great centres of population and manufactures in the middle and eastern states than are Michigan and Indiana, or any portion of the vast region to the westward of those states, while the mineral districts of Ontario, extending along the north shores of lakes Huron and Superior, command as its servant in reaching the great centres of production with its ores and minerals the navigation of the great lakes and the entire network of railways and canals radiating from them, reaching to the seaboard and penetrating the continent in every direction. Quebec, commanding the St. Lawrence and the natural outlet of the great lakes to the sea, is great in the commercial possibilities of the future, and but for the checks placed upon the natural currents of commerce would not have witnessed the diversion of its flow to other channels and the dwarfed growth of the cities that nature designed to number among the leading commercial centres of the world.

The St. Lawrence waterway.

ETHNOLOGIC CONDITIONS.

A homogeneous people.

Canada and the United States are essentially homogeneous in blood. In the face of the fact that a considerable portion of the Canadian population is of French origin and retains the use of the French language, this assertion at first sight may seem too broad. The French Canadian population, however, is loyal to institutions of the English speaking race. It is not alien in the sense of desiring to subvert the laws or polity of the government. Its distinctive characteristics are being modified and the commingling of blood with the Anglo-Saxon is promoted by the growing contact of the two races in Canada, and by the magnitude of the emigration movement of French Canadians to the United States. Its presence in Canada does not forbid the assertion that the two countries are homogeneous in character, social, physical and political. The same tireless energy, boldness of design, and courage in execution are characteristic of both peoples. The same physical vigor, with perhaps a tendency to more pronounced manifestation in the colder and more bracing north, is also characteristic of both. The same love of popular institutions, the same safeguards for securing and maintaining civil and religious liberty, and substantially the same kind and relative strength of religious denominations, are characteristic of both. The same language is common to both; their interests are common. The two peoples have largely commingled with each other through the emigration of Americans to Canada and the much more extensive movement of the native Canadian population to the United States—the latter a movement of such magnitude as to seriously deplete Canada and to promise important results in the near future through the influence exerted on public sentiment in both countries by contact and fusion

Movements of population.

on a scale of such magnitude. Neither dissimilarity in origin, in language, in religion, in laws, nor in education or interest interposes the slightest barrier to the most intimate and extended relations, social and business, between the two peoples.

ECONOMIC CONDITIONS.

To both Canada and the United States Nature has been a prodigal mother. In the resources she has given, each is possessed of boundless wealth. What Canada especially needs is population and capital to develop this wealth. Her economic condition is one of comparative poverty in the midst of fabulous stores of undeveloped riches. Without doubt she is in this respect largely governed by forces beyond her control, and under all the circumstances of her environment perhaps the results attained ought to be considered fairly satisfactory; and, except perhaps in the matter of the exercise of greater care in the increase of expenditure, taxation and public debt, very little more could have been done under existing conditions. But existing conditions require to be changed. The demand is an imperative one. A careful survey of the field shows that the country is in a false economic position. We are prevented from proving to the world our splendid capabilities. It is not for the lack of énergy, intelligence or courage that the Canadian falls short of the most wonderful achievements of any English speaking people. It is not the fault of our political institutions that our economic condition is not more favorable; for our laws are good, and the structure of our government an admirable one that requires only honest and prudent administration to demonstrate its excellence. That Canada does not exhibit as high a ratio of increase in population and wealth for the last two decades or more as the United States have done, and that our economic condition is as unsatisfactory as it is, may be clearly traced in a large degree to commercial belligerency between this country and the United States, mutually discouraging and repelling the convenient, extensive and profitable exchange of productions natural to our immediate neighborhood and geographical affinity.

Canada in a false economic position.

An evidence of the great advantages likely to accrue to us from a relaxation of restrictions upon our trade with the United States is furnished by our experience under the reciprocity treaty of 1854-66. Under that treaty the trade of Canada with the United States increased nearly fourfold. Circumstances of an unusual character combined to lessen the benefits to be naturally derived by us from the operation of the treaty during the last three years it was in force. During that time a fluctuating and exaggerated premium on gold, due to the war and to mad gambling, largely reduced the purchasing power of American currency in the Canadian market, and no doubt interfered with the selling of Canadian products in the American market more seriously than the duties afterwards imposed did when the wild fluctuations in the price of gold ceased. When the treaty expired the state of business in the United States was settling down into its usual channels, the resumption of specie payment was approaching, and the disadvantages of customs duties came just as the disadvantages of gold gambling, a depreciated currency and an unsettled state of business were disappearing; the result being to lessen,

Experience under the reciprocity treaty.

in a degree difficult to estimate, both the advantages derivable from the treaty and the evil consequences of its abrogation, as they would have appeared under normal conditions of business affairs in the United States.

Evil effects of a restrictive policy.

That Ontario has not a population to-day of four millions, or that the Dominion has not a population of eight millions is due to the fact that we are isolated commercially from the thirty-eight states to the south of us. We have not received, and under existing circumstances we cannot receive, our natural share of the energies that are at work in the development of the American continent. By the same policy of restriction that forbids free development of trade between the two countries, the United States is also deprived of a field that would give wide and profitable scope to her energies and her capital. The two countries have an immense diversity of resources and productive capabilities in their vast territory, with its many zones, its wide variety of soil and products, its varied physical structure, its grand sweep of seaboard—arctic, temperate and tropical, nearly encircling its vast domain—its inland seas, its mighty rivers, flowing north, south, east and west, its prairies, its forests, its mountains, its mines and its fisheries. From all these may be derived and set in motion a mutual play and operation of industrial activities which, if allowed with perfect freedom to act and react upon each other within this great land, will produce results that, if foretold, would dazzle the imagination. The great secret of progress and prosperity in the United States without doubt has been the freedom of intercourse between the varied zones of that widely extended land, with its all embracing variety of resources and production. The effect produced by that freedom of intercourse has ceased at the border, where the cordon of custom-houses interposes its hateful presence, paralyzing trade and repressing industrial life to the great detriment of the more powerful and to the untold loss of the less numerous of the two great peoples.

The secret of progress in the United States.

How movements f population re influenced.

Practical considerations of the character alluded to have no doubt given direction to the great stream of emigration that has set towards the shores of America, giving to us very much less than our natural share, and subsequently drawing from us a large number, possibly a majority, of those who had first cast in their lot with us. The same influences have drawn from us a number of native Canadians so large as to have left the evil effects of the exodus clearly discernible in every part of the Dominion.

COMMERCIAL AND BUSINESS CONSIDERATIONS.

Effect of a policy of commercial hostility upon the mining ndustry.

The effect of commercial hostility and ruthless repression by tariff enactments upon the sweeping tide of multiform commercial transactions that would otherwise refresh and vivify every town and township of Anglo-Saxon America is in no department of business more painfully apparent than in that of mineral production and development. In the case of the farmer and lumberman the burdens imposed by trade restrictions are very serious, greatly diminishing the profit of production, preventing expansion of business, promoting the exodus, and in various ways checking the growth of the country in population and wealth. But in the case of some of the departments of mineral production the effect of restriction has been to produce utter stagnation, and in others a state of suspended animation. In this connection the

present condition of various departments of mineral production may be properly contrasted with the condition of similar departments in the United States; and with the natural facilities and advantages possessed by Canada, and particularly by Ontario, for more extended production and development, this contrast will convey its own lesson.

IRON AND IRON ORE.

The condition of the iron production of Canada, and of Ontario especially, is a most unsatisfactory one, and the assertion that the removal of trade restrictions between Canada and the United States would enormously stimulate and develop this branch of mineral production will, after examination of the facts bearing upon the question, admit of no reasonable doubt. The great importance to the world at large of the business of iron production, and the most remarkable increase since the close of last century in the amount of production, will be strikingly shown by the following table:

Wonderful increase of production.

THE WORLD'S PRODUCTION OF PIG IRON.

Years.	Long tons.	Years.	Long tons.
1800	825,000	1875	13,675,000
1830	1,825,000	1876	13,475,000
1850	4,750,000	1877	13,675,000
1856	7,000,000	1878	13,925,000
1865	9,250,000	1879	13,950,000
1866	9,300,000	1880	17,950,000
1867	9,850,000	1881	19,400,000
1868	10,400,000	1882	20,750,000
1869	11,575,000	1883	21,000,000
1870	11,900,000	1884	19,475,000
1871	12,500,000	1885	19,100,000
1872	13,925,000	1886	20,385,571
1873	14,675,000	1887	22,170,959
1874	13,500,000	1888	23,194,501

It will be seen that the increase of production since 1800 has been twenty-eight fold, and that the world's production in 1888 was much the largest of any year in this century of wonderful progress. In the first thirty years of the century the increase was only 1,000,000 tons, but the invention of the hot air blast in 1828 and other very important inventions since that time—notably the pneumatic process of converting iron into steel—have produced marvellous results. At the end of the first twenty years dating from 1830, about which year it may be said that the new era in iron manufacturing by economic processes began, the annual production was increased by nearly 3,000,000 tons, at the end of the second twenty years it was increased by more than 10,000,000 tons, at the end of fifty years by more than 16,000,000 tons, and in the last year the increase was as large as what took place in the first thirty years of the century. The production of 1888 required about 52,000,000 long tons of iron ore, of which Great Britain consumed nearly 14,000,000 tons and the United

Iron product in Great Britain and the United States.

States 12,650,000. The world's annual production of iron and steel is by countries, as shown by the latest available statistics, as follows:

THE WORLD'S PRODUCTION OF IRON AND STEEL.

Countries.	Pig iron.		Steel in ingots.	
	Year.	Long tons.	Year.	Long tons.
Great Britain	1888	7,898,634	1888	3,405,536
United States	1888	6,489,738	1888	2,899,440
Germany and Luxemburg	1888	4,258,471	1888	1,785,354
France	1888	1,688,976	1888	525,646
Belgium	1888	826,984	1888	223,638
Austria and Hungary	1888	761,606	1888	355,038
Russia	1886	541,951	1886	246,000
Sweden	1887	456,625	1887	111,565
Spain	1885	159,225	1887	24,500
Italy	1886	12,291	1886	23,760
All other countries, estimated	1887	100,000	1888	30,000
Total	......	23,194,501	......	9,630,477
Per centage of Great Britain	......	34	......	33⅓
Per centage of United States	......	28	......	30

A suggestive fact.

The foregoing table is virtually for the year 1888. The statistics for the leading iron and steel producing countries are for that year. For Russia, Sweden, Spain and Italy, with a total production of 1,170,092 tons of pig iron and 405,825 tons of steel, the returns are for the most recent years for which statistics are available. A most suggestive fact revealed by this table is that Great Britain and the United States, having about one-fourteenth of the population of the globe, have supplied 62 per cent. of the world's product of pig iron and 65⅓ per cent. of the world's product of steel. The recent rapid growth of the iron and steel production of the United States is shown by a comparison of production in the centennial year 1876 and the year 1888.

UNITED STATES PRODUCTION OF IRON AND STEEL IN 1876 AND 1888.

Classes of Iron and Steel.		1876.	1888.
Pig iron	short tons.	2,093,236	7,268,507
Bessemer steel ingots	"	525,996	2,812,500
Bessemer steel rails	"	412,461	1,552,631
Open-hearth steel ingots	"	21,490	352,036
Open-hearth steel rails	"	None.	5,261
Crucible steel ingots	"	39,382	78,713
Rolled iron, except rails	"	1,042,101	2,397,402
Cut nails in kegs of 100 lb		4,157,814	7,993,591

Bessemer steel.

A striking illustration of the rapid increase in the production of steel in the United States is the fact that the production of Bessemer steel rails for 1888 was 52 per cent. more than the production of Great Britain in the same year.

In addition to the vast production of iron and steel in the United States, the wants of the country required the importation of 1,997,241 short tons in 1887 and 1,024,524 in 1888, in miscellaneous forms, exclusive of imports of machinery, cutlery, firearms and minor manufactures. Of the amount imported in 1887, 1,436,338 short tons came from Great Britain, comprising more than one-fourth of the total British exports of those articles for that year. United States imports of iron.

The tables presented above show the immense volume of the iron production of the world, as well as the remarkable advance made in its production by the world at large and by the great nation to the south of us in particular. They point out the development of this great industry among English speaking peoples, and may be taken as a correct indicator of the commercial position of this race as compared with the rest of the world. They naturally precede enquiry as to the extent of iron production in Canada, and as to the best means for securing more extensive development of our vast iron resources. Supremacy of English speaking people in iron production.

POSSIBLE EXPANSION OF THE IRON INDUSTRY IN CANADA.

In 1887 the per capita consumption of finished iron and steel in the United States exceeded 300 lb., while in Canada the consumption fell short of 200 lb. per capita. As has been previously shown, the output of iron ore in the United States for 1887 was twelve times greater per capita than the output of Canada, while the production of pig iron in the United States was over twenty-one times greater per capita than in Canada. Enquiries have been made as to whether it is not possible under existing circumstances to largely increase our iron production, and it is now proper to enquire as to what might and probably would be the effect upon our iron interests of the removal of all commercial restrictions between the two countries. Per capita consumption and production of iron in the United States and Canada.

The export of iron ore from Canada for the four fiscal years ending June 30, 1888, has been as follows, by provinces:

EXPORT OF IRON ORE FROM CANADA.

Provinces.	Country of shipment.	1885. Tons.	1885. Value.	1886. Tons.	1886. Value.	1887. Tons.	1887. Value.	1888. Tons.	1888. Value.
			$		$		$		$
Ontario	U. S.	52,532	127,542	7,330	22,140	18,907	61,320	13,534	39,590
British Columbia	U. S.	1,835	4,432	200	450	4,440	10,500	......	....
New Brunswick.	U. S.	....	....	12	449	......	....	.....	....
Quebec	G. B.	......	....	......	....	2	10	10	350
	U. S.	.....	....	......	....	38	114	.....	5
		54,367	131,974	7,542	23,039	23,387	71,944	13,544	39,945

All the ore exported from Ontario found a market in the United States. Great deposits of ore can be reached by rail and cheaply laid down at lake Ontario ports. The cost of transportation from the mine to Cleveland, Ashtabula or Pittsburg is not greater, and in some cases is slightly less, than from the mines of northern Wisconsin and Michigan to the same points. Numerous mines not yet available can be easily reached by short branches from railway lines now constructed. Millions of dollars worth of iron ore could be placed in the American markets annually, and apparently the only Convenience of Ontario ores to the American markets.

thing that stands in the way of the development of a great and profitable trade with the United States is the American duty. The magnitude of the shipments of ore to lake Erie ports from Michigan, Wisconsin and Minnesota is suggestive as to the possibility of utilising our own great and hitherto nearly useless deposits. The shipments from lake Superior ports from 1884 to 1888 are shown in long tons by the following figures :

IRON ORE SHIPMENTS FROM LAKE SUPERIOR MINES.

Districts.	1884.	1885.	1886.	1887.	1888.
Marquette range	1,558,633	1,430,422	1,627,383	1,860,043	1,921,525
Menominee range	894,634	690,435	880,006	1,199,343	1,165,039
Gogebic range	1,022	119,590	756,572	1,285,265	1,424,762
Vermilion range	62,124	225,484	304,396	394,252	511,953
Miscellaneous mines	1,879	441	....	....	....
Totals	2,518,692	2,466,372	3,568,357	4,738,903	5,023,279*

A vast lake traffic.

The total shipments of iron ore by rail and lake from the mines of lake Superior since 1850, when the first shipment was made, amounted at the close of 1888 to 40,812,360 long tons. This enormous business has of late years given employment to a considerable part of the lake marine. The value of the output of 1888 at the point of shipment was over $16,000,000, and in its transportation to lake Erie ports American shipping on the lakes earned at least $6,000,000. When this immense volume of business is compared with the trifling export of 13,534 tons from the mines of Ontario in the last fiscal year, it is natural to enquire why the shipments from lake Superior ports should be 340 times greater than the entire shipment from our own province. The shipment of iron ore from the mines of the lake Champlain region to New York and eastern Pennsylvania furnaces amounted for 1887 to 768,852 long tons, or 60 times more than the entire export of ore from Ontario last year. Is it surprising that the owners of Ontario iron mines should eagerly desire the removal of restrictions which keep out American capital that would seek investment in our mines but for commercial belligerency, or should wish to be able to share upon equal terms in the distribution of the millions paid out in American iron centres near our borders for the article of which they have an unlimited supply ?

Suggestive comparisons.

HOW UNRESTRICTED TRADE WOULD OPERATE.

Canada's opportunities under free trade with the United States.

The advantages to be derived by our iron interests from the entire removal of trade restrictions between the two countries would not be confined to the increased sale of iron ore to the American furnaces. The free admission of iron into the American market would in all probability greatly stimulate the production of coke pig iron in Nova Scotia. In Ontario extensive forests of excellent hardwood are contiguous to our beds of ore, and charcoal for the purpose of iron smelting could be cheaply produced in great quantities. With free trade, charcoal iron could be supplied from Ontario as cheaply as from Michigan, and with adequate capital and enterprise there is no good reason under these conditions why a considerable part of the

* The total for 1889 was 7,292,754 tons.

amount of charcoal iron required by the United States should not be supplied from this province. The product of charcoal pig iron in the state of Michigan for the years 1884 to 1887 shows a rapid expansion of the business and a large annual product at the close of the period, as appears by the following table :

CHARCOAL IRON PRODUCED IN MICHIGAN.

Year.	Furnaces in blast.	Tons of charcoal iron produced.
1884	5	34,605
1885	12	125,190
1886	15	148,952
1887	15	180,143

That the business of producing charcoal iron would, with free access to the American market, soon reach a stage of development in Ontario equal to what it has attained in the state of Michigan in four years, does not seem an extravagant prediction when we consider the great natural advantages for charcoal iron production possessed by our province. The production of the charcoal required, amounting to from 90 to 100 bushels of the best per ton of iron, would vastly benefit settlers on the new lands adjacent to iron furnaces, and the employment furnished in cutting and teaming wood, burning coal, mining ore, quarrying limestone for flux, transporting ore and other materials and operating furnaces, would on the basis of the production of Michigan for the year 1887 put over $2,000,000 in circulation as the price paid for labor alone. The erection of furnaces, construction of branch railway lines, transportation of iron and other items of contingent expense would require large additional amounts of labor outlay. The beneficial influence to be exerted upon the interests of the province by the stimulating effect certain to be the result of the breaking down of hostile tariffs between Canada and the United States would in the case of the export of iron ore, and probably of pig iron also, be certain to promote the prosperity of Ontario to an extent greater than any but the most sanguine would venture to predict.

Employment of labor in the production of charcoal iron.

COPPER AND NICKEL.

The vast deposits of copper and nickel recently discovered at Sudbury and other points in Ontario give promise of a rapid increase in the production of these metals. This branch of mineral industry would also be greatly stimulated by free admission of the ore to American markets. The ore from many of our mines could be profitably shipped to American smelting works but for the duty of five cents per pound on the copper contained in it. The cost of erecting smelting works is heavy, and ability to ship ore to the United States free of duty would lead to the working of many mines that must otherwise remain undeveloped. In the case of mines where smelting works have been erected the removal of the American duty on the metal would give a wider market and better prices. The ability to import improved machinery from the United States free of duty would also contribute largely to reduction of cost, and consequently to increase of production.

Stimulating effect of free trade in ore metal and mining machinery.

SALT.

Ontario and Michigan—a striking contrast.

The production of salt has been previously referred to. Ontario in 1887 produced 428,000 barrels. The production of the United States for the same year was 7,831,000 barrels, or 50 per cent. greater in proportion to population than that of Ontario. The production of salt in Michigan has risen from 561,288 barrels in 1869 to 3,944,309 barrels in 1887, or somewhat more than one-half the entire product of the United States for the latter year. Michigan salt was sold in 1887 at an average price of 65 cents per barrel, which was lower than in any previous year except 1886, when it sold for an average of 61 cents per barrel. The opening up of the American market to our salt producers would be a great advantage, not so much from the increased price that would be received as from a vastly extended market that would permit a great increase of production. Our salt field is an extensive one, embracing an area of about 1,200 square miles in the province of Ontario, the brine is the strongest and the purest known, and the quality of salt produced is excellent. The gradual failure of the lumber industry, and the closing of sawmills in Michigan consequent upon rapid diminution of timber supply, will soon remove the exceptional advantages on cost of production hitherto enjoyed by the salt producer in that state, and the free admission of salt to the American market with free coal for fuel might speedily double our salt product, and secure continued and rapid increase beyond that point.

STRUCTURAL MATERIALS.

Market for building stones in the large cities near the lakes.

The value of building stones of various kinds quarried in the United States in 1887, amounting to $25,000,000 as against $552,000 for Canada during the same period, suggests the possibility of a greatly extended trade in that direction. It would be difficult to determine how large a proportion of this $25,000,000 of material was used in the cities upon the great lakes, along the Erie canal and Hudson river, and in New York, Brooklyn and Philadelphia, but the quantity unquestionably amounts to many millions. With free trade in structural materials it seems hardly to admit of doubt that we might secure a large percentage of the trade in building stone with the cities and towns in the lake region, and also with New York and adjacent towns. Lake and canal navigation would give to the marbles, granites and other building stones of Ontario easy access and cheap transportation to all these points, and great excellence of material would enable our quarrymen largely to command the market, cost of laying the material down being equal to that from other points of supply. The duty alone has prevented the growth of trade in this direction, and with the removal of the duty rapid development of the trade would speedily follow.*

Granite, marble and sandstone.

At Garden River, near Sault Ste. Marie, the Commission visited the quarries of the Warmington Stone and Marble Co. Here was found a mountain

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* How great the obstacles to trade in marble, grindstones and building stones are will be clearly seen by the quotations here given from the United States tariff now in force.

438. Grindstones, finished or unfinished, $1.75 per ton.

467 (*a*). Marble of all kinds, rough or squared, 65 cents per cubic foot.

467 (*b*). Veined marble, sawed, dressed, or otherwise, including slabs and marble paving tiles, $1.10 per cubic foot.

468. Manufactures of marble not specified, 50 per cent. ad valorem.

487 (*a*). Stones unmanufactured or undressed, freestone, granite, sandstone and all building and monumental stone, except marble, not specially enumerated or provided for, $1 per ton.

487 (*b*). And upon stone as above, hewn, dressed or polished, 20 per cent. ad valorem.

of marble stated by the owners to be 5,000 feet wide, 8,000 feet long, 600 feet high and of unknown depth, while the band upon which these quarries are situated is supposed to extend inland for about thirty miles. The superintendent of the quarries said: "If the duties were removed we would put up a large marble mill and give employment to some 300 men; but that would not pay as long as the duty is imposed." For the reason assigned by this gentleman, and for other reasons arising out of the operation of the United States tariff, the export of building stone from Canada only amounted to $65,601 in 1887, of which $20,947 was from Ontario, and a trade which might be made to reach millions of dollars annually can hardly be said to be in its infancy.

The Garden River marble.

The product of brick and tile in the United States for 1887 amounted to $47,000,000, of lime to $23,375,000, and of cement to $5,186,000. The export of these materials from Canada is not given separately. In common with some other products they all come under the general head of "other articles," of which the export from Ontario for 1887 amounted to $21,217; showing that the export of these materials, for the production of all of which we have superior advantages, was of the most paltry character in quantity and value. Heretofore all the pressed brick used in this province has been imported from the United States at prices ranging from $25 to $30 per thousand, and until recently it was believed that we had no material in Ontario suitable for its production. But the discovery of beds in the vicinity of Milton and Campbellville, at the foot of the Niagara escarpment, proves that we have an abundant supply of a clay from which brick of an excellent quality is manufactured; and it is now known that extensive deposits of the same kind of clay exist at various points along the base of the escarpment northward through the counties of Halton, Peel, Dufferin, and probably Simcoe and Grey. The manufacture of pressed brick ought soon to become a valuable industry in those districts, which are well served by the Grand Trunk and Canadian Pacific railways, if free access were gained to the United States markets.

Brick, tile and cement.

SCOPE AND RESULTS OF INTER-CONTINENTAL FREE TRADE.

The favorable results that would follow the adoption of unrestricted trade between the United States and Canada as regards the development of the mineral resources of Ontario can scarcely be estimated, and would beyond doubt far exceed popular anticipation. It is easily understood that with the removal of duties would come greatly enlarged transactions in the export of ores of iron, copper, etc., of structural materials and various other articles. It is not so easily understood that the trade repressing effects of duties are not correctly measured by the mere burden that the amount of duty exacted imposes. Every shipment requires a consular certificate. In every entry made at a custom house in either country the shipper must run the risk of trouble about valuation, and the shipment is liable to seizure. He is at the mercy of officials who need care little for public opinion; who, owing to the delay, expense and uncertainty of litigation, are practically superior to the law, and can exercise their own opinion and will, subject to the approval of the head of a department, in a practically irresponsible manner. This feature of the

Repressing effect of duties on international trade.

case deters men from engaging in business who might not be kept back by the mere duties levied, and leaves the few who do engage in business practically without competition.

Mining industries of the United States and Canada contrasted.

The vast increase in mineral production in the United States has been pointed out. A state of great activity is the characteristic of the development of mineral resources in that country. In Alabama, Georgia, Tennessee, West Virginia, Virginia, Kentucky, Arkansas and other states, scores of millions have been recently invested, cities are springing into existence, railway lines are being constructed furnaces erected and great strides in development made. Why should Canada lag behind in this career of development? Why should the great tide of enterprise and business activity sweep by and leave us untouched? The tariff wall serves like a wing-dam to direct the current from us. Remove the dam and the current will reach us in full force. To the wealth and the restless activity of the United States we must look to a large degree for the capital and the skill to develop our resources of gold and silver, nickel, copper and iron. Now we are looked upon somewhat as Siberia is ; a land possessed of minerals, perhaps, but foreign and far away. More than one-half of our mining capital is now American, but it represents only a small fraction of the amount that would speedily seek investment in Ontario if the two countries were commercially one. The influence this change would exert would probably be felt in a more marked degree in the development of the silver and gold mines of north-western Ontario than even in the more seriously tariff-burdened industries of iron, copper, salt and structural material production.

Examination into the character and extent of the mineral resources of Ontario shows even now, when we are only at the threshold of discovery, that they are practically without limit in extent and value. As to the best means of development, we must pick up the courage to make that considerable degree of progress which present conditions will permit, and we must work and hope for the coming of the day when the war of tariffs shall be a thing of the past and we shall be able truthfully to say—

> No pent up Utica contracts our powers,
> But the whole boundless continent is ours.

EVIDENCE AND STATISTICS.

Appended are given: (1) Extracts of evidence bearing upon the question of the probable influence upon mineral development in Ontario of free commercial relations between Canada and the United States. (2) Extracts of evidence relating to the public advantages likely to be derived from the construction of a railway line from Port Arthur to the promising silver mines in the Whitefish valley. (3) Tables showing the imports by quantities and values from Great Britain, the United States and all other countries into Canada of articles of manufacture of iron and steel for the seven fiscal years 1881-7.

INFLUENCE OF FREE TRADE WITH THE UNITED STATES UPON THE MINING INDUSTRIES OF ONTARIO.

Thomas Frood—The commercial barriers between Canada and the United States have tended largely to prevent the development of the mining industry by hindering the employment of American capital in mining operations, and also by depriving us of the American market. If we had free access to the markets of the United States I have no doubt there would be a great increase in the amount of work at the mines in Canada, and a great impetus would be given to the mining industry generally. Most of the capital invested in mining in this district, including Sudbury, is American. Some ore has been shipped to England from Sudbury, and some also to the States. Entering the States there is a duty of $2 a ton on the ore, while there is a very heavy duty on machinery coming into Canada. This is very hard on those engaged in mining, and gives rise to a great deal of complaint.

The commercial barriers prevent a development of the mining industry.

W. H. Plummer—In the Algoma district two or three new companies have been organised, and they are principally Americans. More American than English capital is being invested at the present time in this section. I do not think that so far any company has given the district a fair trial. The interests of English companies are not as carefully looked after as is the case with the American companies. Somehow they fail to get the proper men, and they go into heavy expenditures from the commencement; this has had the effect of discouraging the investment of English capital in the district. I don't think the failure of the English companies should cause any discouragement, however. Their want of success has been due altogether to their injudicious expenditure of money, and I have no doubt that their properties may yet be worked to pay.

American and English capital.

The English companies unfortunate.

P. C. Campbell—The removal of the duties by the American government would tend very much to the development of the mining industry here. Free trade would be the best thing for our mineral development; unrestricted reciprocity is the one thing needed by the district of Algoma. Much more American than English capital is being invested in our mining properties; there is no use trying to sell to English and Canadian capitalists; the only practical men to invest and operate are the Americans. Unrestricted reciprocity with the States would bring in any amount of capital from the American side, and the development of the country would then have the effect of inducing English capital; but the trouble is that the English will send some fellow here that knows nothing about the business. Any development that has been done in this section, with the exception of the Bruce mines, has been done by American capital. The English companies seem to send men out here as managers who don't know anything about their business, or the requirements adapted to this country, and consequently a great deal of money is spent to very little advantage. The Americans, on the other hand, send thoroughly practical men, who understand their business and think of something else than putting on airs. The English works that have failed have generally been unsuccessful on account of incompetent management.

Algoma needs free trade.

American and English management.

Æ. McCharles—The removal of the duty on iron ore would have, I think, the effect of inducing Americans to invest in iron lands on this side. If machinery were allowed to come in free it would help mining in this section. Anything that would tend to cheapen the expense of developing property would have that effect. Our iron is as good as any the Americans have, and our salt is a great deal better. In Michigan the production of salt has increased immensely within the last few years, while here it has remained stationary. That is owing to the duty, and were it removed the increase in the production of salt in this country would be immense.

Effect of duty on iron ore, mining machinery and salt.

John S. Skewes—If the duty were removed and lead ore allowed free into the States, I think it would be fully as good a market as England. If that market were opened to us we could resume work at once and carry it on successfully; we could ship the are direct to Chicago. We are only nine miles from a shipping point, and the winter roads are good.

United States market for lead ore.

R. E. Bailey—Of course the removal of the duty would be to a certain extent beneficial. Freer trade between the two countries would no doubt help the development of the mining properties here; it would encourage people to come here.

Removal of the duty would be beneficial.

James Stobie—For iron and copper I would expect to find a market in the States. I think the smelting could be done here, as the importing of the coal would be cheaper than the exporting of the ore. There is no doubt that the American duties greatly interfere with the development of iron and copper mining.

Iron and copper.

The duty hinders trade. *Dr. Edward Peters*—Were the duty taken off it would of course be a gain to that extent, unless the price fell and thus offset that advantage.

Francis Sperry—It would be a very great advantage to have free entrance for our ores to the markets of the United States.

Duty on machinery. *Francis Andrews*—The machinery we use at the Sudbury mines is imported from the States, the duty being 35 per cent. It would assist mining very much if machinery were placed on the free list. We have imported about $15,000 worth of machinery and will soon have to import a great deal more—$20,000 or $30,000 more.

Copper. *B. E. Charlton*—If the American duty were removed off copper it would be a great help. If it were removed small mines could be worked.

Machinery, iron, silver and galena. *S. J. Dawson*—Some of the machinery requisite for mining can be obtained in Canada; other parts cannot and have to be imported. I think it would be wise to admit such machinery as is not manufactured in the country at a nominal duty. For iron the market is in the States. Silver so far has been sent to the States, but on silver there is no duty; it enters free. On galena there is a very heavy duty. In the case of galena containing silver being shipped, if the silver were the more valuable it would go in free, but in some cases the examination of the ore to ascertain the quality might embarrass the exporter. If soft coal were allowed in free the ore could be smelted here. Coal costs in Cleveland from $1.75 to $2.50 a ton; the freight to Port Arthur is 70 cents and the duty is 60 cents. You can well understand, therefore, that the removal of the duty would make a great difference. The mineral resources of this district are now attracting more attention than ever before, and more men of capital and experience are coming into the country. Most of the capital that is coming in is from the United States. Development without foreign capital would be very much slower; the bulk of the capital is American, but there is some English.

Machinery for silver mining. *Thomas Hooper*—The tariff works against us very much. The manufacturers of Canada are not at all up to the times in the manufacture of mining machinery, or in anything else that belongs to mining. In order to get the best we have to go to the other side of the line, and if we do not get the best it is better to not get any at all; the most modern and most improved machinery is what we want, and we must get it no matter what the duty is. The duty is 30 per cent. Candles are quite an item with us in mining. We must have candles made without grease; they are not to be had in Canada and we have to import them, the duty being 5 cents per pound and 30 per cent. The candles that we use are made of mutton tallow, paraffine wax and resin. Anything that we export does not pay duty, but anything we import to improve the country pays an exorbitant duty. I have seen good iron ore here, but it could not be shipped at all on account of the duty; the removal of the duty would be necessary to render it possible to mine iron ore in Canada.

Iron ore.

Mining machinery. *T. H. Trethewey*—Our machinery at East Silver Mountain mine, with the exception of our drills, has been got mostly in Canada. Our pumps were manufactured in Toronto by Williams. I do not think if we were erecting our stamp mill that we could get the machinery in Canada; we would have to import at any rate most of it. The removal therefor of the duty on machinery would be a great assistance to miners. What machinery we have purchased in Canada has been very good.

Henry H. Nichols—If we build works it will be necessary for us to import a great part of our machinery, and I think the government should allow that which cannot be had in Canada to come in free.

Iron ore and smelting plant. *Peter McKellar*—If the American duty were taken off iron we would have a market at once in the United States. It is not certain that we can do anything with our iron till the duty is taken off. It might be smelted here with the protection of the present duty, but in that case machinery would have to be imported, and it would help us to have the duty taken off that machinery. It has mostly been American capital that has been invested in mining here.

Capital, markets and railway communication necessary. *James Conmee.*—By far the greater amount of capital in the mines and quarries here is American. The iron locations on our side are not being developed because of the American tariff and the want of a railway. The railway would be a cheap one to build, and with that railway built and the duty taken off the ore, there would be a great future before the country. We have got neither the capital nor the markets; we require both, and we would get both if the duties were once removed.

Some of the machinery that is used in mining can be got in Canada, but a great part has to be imported from the States and a heavy duty has to be paid.

William Margach—Nearly two-thirds of the land taken up in the Hunter's island district has been taken by Americans, and much the greater part of the capital is American. A railway is badly wanted; but iron will not be worth anything to this country till the duty is removed. The Americans are purchasing under the impression that a railway will be built, and hoping that the duty will be taken off.

Iron ores in the Hunter's island district.

D. F. Burke—It seems to me the mineral whose development would do the country the most good is iron. If we had reciprocity we could put out at least \$8,000,000 worth of ore a year, and that amount of money would come annually into this district. There seems to be no doubt, judging from the reports of experienced men, that iron exists all over the district of Algoma in very large quantities. A railroad would do much to open up the country, but there would still be the duty of 75 cents a ton to fight. The Attikokan location would have been purchased by Americans if they had not thought there would be trouble between the two governments, and that their capital would be unsafe on that account. If reciprocity were adopted, I have no doubt that inside of three years we would ship out at least a million tons of ore per annum; that is supposing the railway to be built as well. The same railway would open up at least 175 miles of good agricultural country out of 300, the length of the line. Part of the country across Thunder bay is all white sandstone, while the red sandstone of Nipigon is famous. If we had reciprocity, inside of five years a great trade in building stone would be opened up between here and all the great cities in the States. There is a red granite here, said to be equal to the Peterhead, and there is a pretty serpentine marble upon the Nipigon river close to the Hudson bay post.

Free trade would encourage iron mining and sandstone quarrying.

Joseph Bawden—We should find a market for our iron ores at Chicago and Pittsburg. We can send ore to Chicago from Kingston for less than it can be brought from the lake Superior mines to Chicago. I think we could find a good market there. The tariff is the chief, in fact the only interference with successful mining in this region. If the duty were removed the country would develop and mining would go on. The capital invested in mining in this section is nearly altogether American, except some little Canadian. The Bedford company is a Canadian company. The Kingston & Pembroke has absorbed all the other companies. Its capital is \$5,000,000 all paid up. Property is put in to represent it, except a certain amount of stock that was sold for working capital.

The market for iron ore.

Capital invested in mining enterprise.

B. W. Folger—Most of our ore goes to Cleveland. The Wilbur ore goes to Pittsburg; they seem to like it and say it is as good steel ore as they get. Ore running 55 per cent. would sell at Kingston at from \$3 to \$3.50 a ton. The freight from here to Cleveland is 75 cents, or less than half what it is from lake Superior. If the duties were taken off we would get that much more profit and it would greatly encourage the developing of properties.

Frontenac and Lanark iron ore.

Nathaniel Moore—I am favorably impressed with the occurrence of iron in the Kingston district. I believe there is plenty of ore here and of good quality. While the veins may not be as large as those of the lake Superior district, I think that as far as length and depth are concerned they are as good. I cannot speak in regard to that from experience. I worked long ago on the old Dalhousie mine, and I do not see why the veins should not be as good. As to quality, I think they compare very favorably with the lake Superior ore. Of course here there are advantages in the matter of freight, but there is the duty against us. We may have a little the advantage in cheaper labor, but there is not much difference.

Quality of eastern Ontario and lake Superior ores compared.

J. S. Campbell—I cannot say whether we will resume work at our Calabogie mines. If the American duty were removed we could resume and mine profitably.

Calabogie iron.

W. H. Wylie—If the American duties were taken off it would help to develop the iron properties, but I do not know that it would benefit the other ores.

Wm. Caldwell—There has not been a good market for our own iron ore for the last few years, while there has been a very large development in the United States. If the American duties were removed we could compete with the American mines successfully.

Iron ores.

R. C. Clute—I think it is impossible to develop our mines unless we have free trade with the United States. I think the present law excludes capital, and both capital and market are required. It would be possible to smelt iron here under a high tariff, just as it would be to raise oranges, but it would not benefit the people.

American capital and market required.

I have had communication with people on the other side, and am convinced that there would be no difficulty in developing our mines if we had free trade with the States. If we were on equal terms we could compete with the iron ore of the lake Superior district. Our position is very favorable, yet with all in our favor we have been able to do nothing, while from northern Michigan some three million tons were shipped last year.

Our natural market.

W. H. Wallbridge—The American is the natural market of this country, and is necessary to the development of our mines.

Free trade or a higher duty.

William Kelley—What is wanted to develop the mines of the country is unrestricted reciprocity or commercial union, and if the Americans will not take off their duty we will have to put on a higher duty. If the Ontario government would give a bonus of $3 a ton it could be manufactured cheaper than it can be imported.

Canada's prospect under continental free trade.

George Hope—I do not think mining ever will amount to anything in this country till we have commercial union. There is one firm that I am told is willing to invest $12,000,000 and put up works if they can get the American market for their production. Our ores could be laid down cheaper at lake ports than the lake Superior ores.

A stove manufacturer's opinion.

Adam Laidlaw—If we had the American market I think we could compete, though I know that is not the opinion of some people. We would make special lines and in that way could well hold our own. At present we make our stoves just as good as the Americans do. Take a Canadian stove and an American stove made from the same patterns and you cannot tell them apart.

Cost of iron ore production.

Thomas Ledyard—The only thing that can be done with our ore at present is to send it to the States. Pittsburg is the best place to ship to by all rail. The freight to Buffalo from the mines would be $1.50, where there is a charge of 25 cents a ton for shunting; freight from Buffalo to Pittsburg, $1.25. The duty is a serious drawback to that trade. If the duty were removed our mines could be developed as well as the Michigan mines. The cost of mining would be from $1 to $1.50. We would have an advantage of from $1 to $1.50 a ton in freight over the lake Superior ores. The price at Cleveland of Bessemer ore is $5.75. The duty is the great obstacle. If the Belmont mine was being worked at the rate of 400 tons a day that would mean duty to the extent of $300 a day. It is estimated that 4,500,000 tons were shipped from lake Superior this season, and that in the face of a dull steel rail market. In addition to all this, in 1887 1,100,000 tons were imported into the States from Europe. As far as the Canadian market is concerned, six good iron mines would supply the whole of Canada, even if we used all our own iron. That is estimating the consumption at 600,000 tons of ore, and of that only about one-third of magnetite could be used; they don't like more than that proportion of magnetite in the furnace. I am satisfied we have more than a double supply of magnetite. Our magnetite mines would supply the whole of the Dominion, but that ore cannot be used by itself economically.

Canada's limited market for iron.

American and European markets.

James Proctor—We want the American market, but I do not think we can compete with Europeans. I do not think there is any use mining iron and copper ore and sending it to Europe.

An obstacle to development.

H. S. Howland—I am a merchant residing in Toronto, and am interested in mining properties. I have an iron mine in the township of Snowdon. I have leased it, and I do not know whether it is being worked at the present time. The shaft is down about 80 feet, and they have taken out a considerable quantity of ore and shipped it to Elmira, N.Y. I do not think the venture paid very well, or they would have gone into it extensively. If the American duty were removed it could be shipped with profit. I think that is the obstacle to the development of the iron industry.

Value of the United States market for iron ores.

C. J. Pusey—All the ore we have so far taken out of our iron mine in Haliburton has been shipped to the United States. It is our only market; we could not ship to the old country. The duty is the only thing that prevents us supplying the American market. If the duty were taken off the value of our mining properties would be increased, and we would be able to compete with the American mines in Michigan and elsewhere. If the duty were removed by the American government I can see no reason why our mines should not be developed as fully as those of Michigan. Taking the ores through that range in Haliburton and eastwards and comparing their analyses with those of the ores on lake Superior or any other point of the United States, or even the Spanish ores, I claim that there is a greater proportion of Bessemer iron in the Canadian ores than in the others mentioned.

Albert Carpenter—We use soft coal in burning sewer pipe, and the duty is a very serious item. We use from 24 to 30 tons a week. There is also a duty upon the clay that is imported. The duty on sewer pipe is 30 per cent. I do not think that if the duty were taken off we could compete with the Americans on equal terms; they have the clay and the coal in the same bed. Some of the factories in the States use natural gas, and of course t at is an advantage; but for that the cost would be about the same. Sewer pipe.

Moses Snow—There is a small duty on building stone, and of course we would be better satisfied if there were no duties at all. If the duties were removed we would put up a large marble mill at Garden River and give employment to some 300 men, but that would not pay as long as the duty is imposed, and it will be shipped as building stone. Marble.

W. H. Laird—Nearly all the capital invested here is American. At the East Silver Mountain mine there is English capital invested to the extent of about $225,000, and in other properties I think there is about $600,000 of American capital invested. I am interested in the sandstone quarries at Grange island and Verte island, and a Chicago company is also working a location of 80 acres. We have in those two islands about 2,500 acres. It is red sandstone, the same as the Chicago property, and we have spent about $5,000 in opening up one of the properties. I do not know what depth it goes to, but it rises about 100 or 150 feet above the water level. We spent the money to get at the place where the stone was solid The cliff is a mass of this red stone. On both islands it is near the margin of the lake, so that vessels could get to the property almost anywhere. The United States would be the market for that stone. The stone that is now being shipped is exported in its rough form and is subject to a duty of $1 a ton. The architects like the stone as it stands a great pressure and resists the effects of climate, but when capitalists come to look at it they find the duty in the way and this prevents anything being done. If the duty was taken off there would be no difficulty in operating the property. Sandstone at Grange and Verte islands.

Thomas Marks—I think it is the duty that prevents our sandstone being largely used. If it were taken off I think we could work the quarries to advantage and could compete on the American markets. The demand for it would be enormous if once introduced, and I think 500 men would be employed in quarrying, besides those engaged in dressing it. The duty upon iron ore is very injurious to mining development. It would also be well to have the duty taken off such machinery as is not made in Canada. Sandstone, iron and machinery.

Edward J. Whitney—The capital of the Hungerford Marble company is $100,000; the stock is held in Canada and P. W. Ellis of Toronto is the president. We hope to find a market for some of the marble in Canada, but it is expected that the greater part will be disposed of in the States. Entering the States there is a duty of 55 cents a cubic foot on block marble, but in spite of that there will be a great demand for this marble as soon as we are in a position to supply it. The duty on dressed marble is very much higher than on block marble; the duty of course interferes to that amount. If the duty was taken off it would put us on an equal footing with the American quarries, and by so doing would give us a chance to develop to a much greater extent than is possible under existing circumstances; and we could figure on a better profit and therefore would develop to a great extent. My experience of the American marble market extends over a period of twenty-five years; I am well acquainted with the different kinds of marbles required, and am perfectly satisfied that this marble will take well on the American market. Most of the quarrying machinery used has to be imported and to pay a duty of 30 per cent.; the machinery cannot be got in Canada. It would be a great advantage to allow machinery in free where people are trying to develop property. The value of the machinery put in here—not including the diamond drill which is free—is from $6,000 to $7,000. The market for Madoc marble. Machinery.

Alexander McLean—I think that what is wanted in this country is a wider market; we have an abundance of the material, but not the demand for it. I think they have crystalline marbles in the northern parts of Europe; if they have not, at any rate they have other stone we would have to compete with if we sought to find a market there. An experiment of that kind would entail a very large expenditure. The American market would be much more promising. We have crystalline marble and other stones that we could sell in the States without doubt. I do not think they have a very considerable amount of crystalline limestone in the States. The American market is the market for building material. There is no market No prospect of a European market for marble or building stones.

here that will justify the expenditure of much money. If we had the American market we could ship from Kingston to Chicago; we could get a rate from the Thousand Islands to Chicago of a dollar a ton. I do not know the rate to Liverpool, but it would be very much more than that. I think if there was an extensive opening up of the marble quarries we might be able to get lower railway rates. In order to attempt to compete with the old country we would have to produce very cheaply. Colored marbles are what take the markets. I do not look upon the outlook for the marble trade in this country as good till such time as we have the American market. Here there is no market to justify people in putting money into quarries. The amount of native marble here used is only a trifle. Most of the marble used in Canada comes from Italy and the United States, the greater quantity from Italy. A considerable quantity of marble is used in Canada, but it is really not a large quantity; the market is very limited, and that is the great difficulty the trade has to contend with here. We have the market now as completely as a high tariff can give it, but it is not large enough to support one quarry on a large scale. Then in one respect marble is very like dry goods, certain kinds are fashionable. Just at present the popular marble is the Tennesee; it is red, with white and variegated spots. There is no marble we produce that is at all like it. Those we have are principally crystalline limestone. I have seen some very fine marble in color and texture that came from back of Tweed, from a quarry that belongs, I think, to Mr. Sanford of Hamilton. The color is white, and it is much less crystalline than the Bridgewater marble, but we cannot tell anything about that property till it is developed. I do not wish to be understood to say that crystalline marble would not compare favorably with other marbles for useful purposes. I think it will last better than any other marble, and I do not think it will stain as easily as the Italian marble. It would not take quite as good a finish as the best grades of Tennessee marble, but of course I have only seen what may be called surface specimens. I think the present duty is satisfactory, and I do not think that an extra duty would help the business any. I have heard that this country is made a slaughter market of by the States, but I do not think that amounts to much. We have bought Tennessee marble ourselves in the open market. Fashion rules the demand, and there is not so much marble bought by one person that the duty would make any difference. The furniture dealers will not take marble that is not in the fashion; people will not buy an article that is unfashionable. It is impossible to force Canadian marble on the market. We have no opposition in granite from the United States. There is any quantity of fine granite in the Muskoka and lake Superior districts. It is said that it has been used for bridges, and that it is free from checks and cracks. There is no object to go into granite the way prices are now unless we get special orders. We are not making any great effort to develop that trade; but the marble business is developing rapidly.

A limited home market.

Fashionable marble.

Crystalline marble.

The present Canadian duty satisfactory.

Granite.

Dr. Timothy Coleman—There is no market at present for salt, and there is no profit in the business. If we had free trade with the United States it would do a great deal. In Montreal there seems to be a prejudice against us. I do a fair trade with the French, but the English-speaking part of the population think there is nothing like the English salt. Unless we get annexation, commercial union, reciprocity, or something of the kind the salt industry will die out. We should be allowed to import coal free for the manufacture of salt.

Salt wants a larger market.

William Gray—The eastern provinces do not want a duty upon salt, but as long as salt is allowed in free there should not be a duty on coal. If we had the American market it would be a good thing for us; we could hold our own against the Americans.

Free salt and taxed coal.

John Tolmie—I do not know of any way in which the Ontario government could assist the salt industry. If the duty were taken off it would help us materially. I do not think we could now send salt to the States even with a bounty. We would get only $4 a ton in Chicago, and out of that there would be the freight $1 and duty $1.60. If the duty were returned as a rebate it would pay. A duty on English salt would help us very much. The consumption of English salt here is a million barrels, and that of Canadian only 300,000 barrels. That and reciprocity with the States would help us greatly.

Excluded from the States.

Free English salt.

John Ransford—The principal thing that tells against the salt industry of Canada is the duty on coal. We cannot use the Nova Scotia coal on account of the freight, and there is no other coal we can use except the Ohio. Bituminous slack is commercially valueless; the mine owners charge us less than it costs to put on the

The tax on fuel.

cars. They sell it at 10 cents a ton on board the cars, and because there are a few large pieces that it will not pay the miners to take out we have to pay a duty equal to six times what it costs at the mines. We want free coal, as well as other articles that enter into the manufacture of salt. If we cannot get these articles free, then we want a tax on salt coming into the country. The tax of 10c. per 100 pounds should be collected on all salt except what is actually used by the fishermen. We have spent thousands of dollars and months of time in trying to get the government to do something. I am opposed to the principle of bonuses, but any remedy would be an improvement on the present state of the industry, which is the most oppressed in the country. With free trade and the American market we would be able to hold our own against the American manufacturers; we have confidence in the quality of our brine, and in our ability to hold our own. If with a fair field we could not compete with them, then the sooner we closed up the better.

Free trade and the American market.

Peter McEwen—The removal of the duty on coal would benefit the salt industry here, but I do not think the American duty makes much difference. If we had free trade they would beat us out of part of our market, but we could take part of their Chicago and lake trade. We would not fear them on equal terms. A tax on English salt would help us. The English salt drives us out of our own market. The exclusion of that salt would be the best thing for a while. I am personally against protection, but as other articles are protected I think salt should be also. The English salt comes out as ballast; their labor is about half what it is here, and their salt is only about 300 feet down, and they can send from England to Toronto as cheaply as we can. As matters are at present not more than a million people use our salt. No doubt that free trade would greatly benefit the country; I mean free trade with the States.

United States and English competition.

Joseph Williams—The duty on coal does not affect me, but it is an injustice to others and should be taken off. If we had free trade with the States I would not be afraid of being able to hold my own against them; if they sold here we could go there for our market.

Taxed fuel an injustice.

James Carter—If we had a free market I don't think we should have anything to fear from American competition. I don't think they could compete against us in Ontario. If the duty were put on the English as it is upon the American salt it would give the manufacturers here an opportunity of supplying nearly all the salt consumed, and that is about one and a half times more than is now being produced by Canadians. It is questionable whether that would be an advantage to us, because the salt industry is so overdone that there are now five times as many works as are needed to supply the amount consumed, and if English and all American salt were excluded it would only increase the consumption one and a half times. We could not advance the price, as business would still be overdone to the extent of double what was required. Matters would arrive at the same point they are now, and the only remedy would be to combine. It would only cause works now in existence to start up; it would cause more production, but not at a profit. I do not think it would be for the benefit of the people at large to exclude the English salt, and I think it would be a hardship on the consumer. I think the tariff is very unfair and nonsensical in that it makes us compete with English salt here and pay duty on the fuel that we import, which is equal to 3 cents a barrel. Now we have to pay that and to compete against free English salt. As to making salt pay duty and allowing a rebate on all used for the fisheries, I cannot see that it would do the salt manufacturers any good. They would get the English salt just the same as now, because the freight is cheaper. It would be an annoyance to them without doing the Canadian salt manufacturers any good.

An unfair arrangement of duties.

The English competition.

An overdone business in a limited field.

John A. Barron—As far as I can judge not much can be done till we get a market; the Canadian market is too limited. In order to supply a market for the excess above home consumption, it is necessary that we have access to the American market. Free trade with the States I look upon as the most important thing for the iron industry. If we cannot get the American market then the home market is better than nothing, and we should do what we can to make the most of it. Half a dozen mines would supply our own market, and if confined to that there would be the danger of over-production, which would be attended with disastrous consequences.

The Canadian market is too limited.

W. H. L. Gordon—I reside in Toronto, am a barrister and am also a commissioner of the Canadian Land Emigration company. The company owns nine townships in the Haliburton district. The land was bought for settlement purposes over twenty-five years ago, but it is more of a lumber and mineral than an agricul-

Minerals in Haliburton, but no prospect of working them without an American market.

tural country. We have done a good deal of exploring and have discovered iron, copper, apatite, galena and molybdenum. We believe that iron is to be found in the largest quantities in Dysart, Dudley and Harcourt. There are indications of large quantities in both Dysart and Harcourt. Nothing can be done with iron in the present state of the market owing to the duty of 75 cents, which shuts us out of the American market. This section of the country is within 120 or 130 miles of Toronto. The development of mining there would be the greatest boon to the settlers. The lumber is fast disappearing, and unless the mines are developed they will be in a bad way before long, especially as it is not an agricultural country.

Ways of fostering and injuring the mining industry.

E. B. Borron—The federal government has not been at all successful so far as this province is concerned. Whatever has been intended, the effect of its legislation has been to crush rather than foster our mining industries. The power to injure is undoubtedly possessed by the federal government. One way in which this may be accomplished is by imposing exorbitant duties on machinery, and everything in the way of stores and materials used in mining, dressing and smelting the ores, thus greatly increasing the cost of production. The other way is by pursuing a policy calculated to deprive mining companies of their best and nearest market. And how seriously that may retard the development of her mineral resources must be apparent to all. It may be supposed by many that the customs duties charged on metals imported into Canada may compensate for the burdens otherwise imposed by the tariff, but a little reflection will show that this is not the case. The tariff imposes no duty on the importation of gold and silver, nor would it be of the slightest advantage to our gold and silver mines if it did. The tariff places a duty however on iron, copper and lead. But we have no mines in Ontario which produce iron, copper or lead in the metallic state, nor any so far as I know at which the product is smelted and sent to market in that state. Ours are strictly speaking iron ore, copper ore and lead ore mines, and the product is transported to market and sold as ore. As may be seen by reference to the tariff, ores of metals of all kinds are admitted free. So long as there is no smelting works or furnaces in Canada, duties would be of no benefit. As regards other minerals, many are produced in quantities greater than required for Canadian consumption and must be exported, in which case the import duty in the absence of combinations does not necessarily increase the price. It is therefore evident that whereas our mining industries are oppressed by the tariff on the one hand, they really derive no equivalent or advantage whatever from it on the other hand. The duties on imported copper, lead, iron, etc., are really of benefit only to the smelters, or those mining companies that smelt their own ores, of which I do not know of any in Ontario unless it be at Sudbury. In the case of those mines that sell their product in the shape of ore, these duties are even an injury, increasing as they do the cost of engines, machinery, pumps, rails and tools, in fact everything into the manufacture of which those metals enter which is required for the working of the mines. The best thing the federal government can do is to remove all duties from off the machinery, materials and supplies, manufactured and unmanufactured, required for mining, ore dressing and smelting operations and abolish the protective duties on metals. If it is deemed necessary to protect the smelters of iron, copper or other metals, let it be done by giving bounties, which have this advantage that we know precisely what we are paying. From the table showing the value of the minerals exported by Canada, as given in the report of the Geological Survey for 1887, it appears that the total value of the minerals exported from 1874 to 1886 was \$43,-653,770, of which \$33,437,497 was exported to and sold in the United States. Nothing more than this is required to show the importance of that market; and how necessary it is the federal government should spare no effort to remove every obstacle to the freest trade possible between the two countries. The value of the minerals exported from Ontario alone, as may be seen from the same report, has fallen from \$955,820 in 1874 to \$186,574 in 1886; or, in other words, the production is only one-fifth part what it was thirteen years ago, for all the minerals produced by our mines, with trifling exceptions, are exported. This reduction in the quantity and value is principally due to the suspension of operations by the Silver Islet and West Canada mining companies,—the former, it is believed, in consequence of the exhaustion of the mine, and the latter partly in consequence of decreasing richness of the veins in depth, but chiefly owing to the extremely low price of copper ore. In the present depressed condition of our mining industries the federal government should remove the burden imposed by unequal and unjust taxation, and pursue a policy which will lead to the free admission of our mineral products into the United States. Our mining industries never stood in need of consideration at the hands of

Customs duties.

The bounty system.

Our export trade of minerals.

Free trade with the United States desirable on a permanent basis.

the government more than now, and until they receive this consideration and our commercial relations with the United States however free be placed on a solid and permanent foundation, not merely dependent on the political exigencies of a party or the whim of a minister of finance, I do not think American capitalists will invest much money in our mines, or that our mineral resources will be developed to any considerable extent or with any satisfactory results.

H. P. McIntosh—The customs duties are not only burdensome, but their collection has been very annoying, and many times the work of the Canadian Copper company has been brought to a standstill on account of the delay caused in this department; however, I will say of late that this business has been transacted in a more satisfactory manner than formerly. To avoid delays our company has offered the government to furnish an office for the customs officer at Sudbury free of charge, and also to pay the salary of the officer, so that goods consigned to us might go through to Sudbury instead of being stopped hundreds of miles away, but this offer the government declined. There should be no duty on mining machinery, nor upon any tools or implements used either in the production or smelting of ores, or for refining the product into pure metal. Coal and coke used as fuel should also be free. No substantial progress will ever be made in the development of the mineral resources of Canada until the policy of the government is changed from one of exactions upon this industry to one of encouragement and support. The imposition of a tax on mining machinery, which of necessity is imported into Canada, is nothing less than a premium offered to allow portions of the country, now practically worthless, to remain forever just as nature left them. It is more than that—it is in the nature of an edict that it should remain so. Nearly the whole railway system of Canada has been built solely by the government, or largely so by its generous aid. It would seem to be the most natural thing in the world that they should now give some aid to those who risk their money in these enterprises to develop the country through which long lines of these roads traverse. The United States senate has within the last few days voted a bounty on the production of sugar, which during the existence of the law will amount to many millions of dollars to the producers, and this to an industry nearly a century old. It has also at the same time cut down the import duty on many of the minerals to one-sixth of the former prices. We do not need to go further than to call your attention to the figures already in your possession as to the relative condition of the mineral products of Canada and the United States. The successful development of your mineral resources is one wholly dependent on your governmental policy. Your governments, both Dominion and Provincial, should offer a bonus on the production of ores and upon the product smelted from them during a term of years sufficient, and of sufficiently generous amount, to warrant the investment of capital in these enterprises. It should also offer special inducements in the way of an extra bonus for a designated large output both of iron and other metals produced during a period of years.

Customs delays.

Exactions upon industry.

How encouraged in the United States.

Bounty on production of ores and metals.

THE CONSTRUCTION OF ROADS AND RAILWAYS A NECESSARY PART OF A GENEROUS MINING POLICY.

S. J. Dawson—A railway has been projected from Port Arthur to Gunflint lake, a distance of 85 miles, and the Dominion government has appropriated $3,200 a mile for the whole distance; ten miles has been already graded and a quantity of material has been purchased. This railway when completed will make the silver mines of the district accessible as well as the iron mines; in addition it will open up a section of fine agricultural land, as the whole of the valley of the Whitefish is the best of land and well adapted for farming. The line has been surveyed, and the engineering difficulties are not much. It will be easy of construction and the amount of rock excavation will be small. Beyond the head waters of the Whitefish there is a great deal of good land and a great deal of very good pine. Were the railway constructed it would open up a dozen townships of good agricultural land in the Whitefish valley, besides what there is beyond. I think $20,000 a mile would be a high estimate for building and equipping the road. There is an unlimited quantity of white poplar in this district which would answer for the manufacture of paper pulp. It is of large size and good quality. The opening of a railway would lead to the establishment of that industry as well as several others, in addition to developing the mining capabilities of the country.

A railway line from Port Arthur to the international boundary.

Farming lands.

Poplar for paper pulp.

William Plummer—Where any mining development takes places I think it is a wise policy on the part of the government to build roads.

A wise policy to build roads.

Thomas Hooper—We use a great amount of fuel, and the forests here will not supply us long. When we work with a full force at our present capacity we clear two or three acres every two days. We require about 450 acres annually even at our present capacity so that it will not be long before we will have to come down to coal. If we don't get a railway inside of three years there will not be a tree seen in this part of the country. The fuel is poor; one cord of good maple is worth three of poplar. Since the 17th of March last to date we have paid the Canadian Pacific railway for freight $1,394, chiefly for freight from Port Arthur. In the Whitefish valley 60 per cent. of the land is good for settlement; the soil is a clay subsoil with a sandy loam. I cannot tell you about the frosts, but I never saw better potatoes than were raised within twelve miles of here.

The need of a railway to bring fuel to the silver mines.

Farming land.

Wm. Murdoch—A railway to the district west of Port Arthur would do wonders to develop the mining industry, and I am convinced that the traffic would pay from the beginning. It is necessary to the development of the mining industry, and would bring capitalists into the country. The Fraser-Chalmers Co. of Chicago export mining machinery all over the world, and were the industry developed here I believe they would start a factory here. In the meantime I think it would be wise to allow machinery not made in Canada to come in free.

The value of railway service in a mining country.

Henry Rothwell—The starting of smelting works by the government would no doubt do some good, but everything hinges upon the railway. If we had a railway it would give a great impetus to the silver mining business; the woods would be alive with prospectors, and capital would come in freely. I know a great many claims in the neighborhood that are lying idle and cannot be worked owing to the want of a railway.

The want of railway communication delays mining development.

W. N. Montgomery—Quite an amount of ore has been taken out of our mine, but none has been shipped as it cannot be shipped profitably from this point on account of the freight, which is so high. To ship freight to Port Arthur costs one cent a pound, and this spring I had to pay as high as two cents. A railway would enable me to handle the ore properly. I think it would be better to treat the ore here than to ship it, as then light grade ore could be worked.

Heavy cost of freight.

T. H. Trethewey—The construction of a railway to the Silver Mountain mine would result in great development and in increased prosperity. I believe there would be business enough from the beginning to pay, and a rapid and steady increase in the volume of business the road would do. Colonisation roads, even if in good condition, will not answer, because freights would be so high that it would be impossible to go further west than here on such roads.

Prospects of traffic to the Silver Mountain mines.

Henry H. Nichols—Before there is any development of any account at Silver Mountain there must be a railway. As it is now freight from here to Port Arthur costs $1.50 per 100 lb., and nothing but the richest ore will stand that. We propose to develop our mine, but we must wait for better shipping facilities before we can do much. This section cannot get on any longer without a railway, and I think a railway would create a regular boom.

A railway to Silver Mountain a necessity.

George A. Shaw—I am interested in West Silver Mountain mine, and it is our intention to put up a large stamp mill there. We got some of our machinery from Toronto and some from the States. I think we can get all we want in Canada. There are certain kinds of machinery that I think should be allowed to come in free. But what retards mining development there more than anything else is the want of a railway and good roads. It would cost about $20 a team for each trip now from Port Arthur to Silver mountain. A team could take a ton in the winter, but in the fall and spring it could not take half a ton.

Machinery.

A railway and public roads needed.

Arthur Harvey—I live in Toronto and have taken a deep interest in mining matters for the last twenty or twenty-five years. I am interested in the silver district west of Port Arthur and the gold district at Rat Portage. I am interested in three or four silver locations, only one of which has been partly developed, 230R; it is northwest of Whitefish lake. We put down two shafts of 25 or 30 feet, but we are stopped till a railway is built. Everything is very promising, but we do not think that we can do anything till we get a railway. The distance to Port Arthur is about 55 miles. I think a railroad built there would lead to very large developments, and the first 40 or 50 miles of it would pay from the very start. It is the experience in Colorado that three good working mines will keep a railroad. I think the railway question is the only one that the government can deal with in the interest of mining development.

Promising work stopped for want of railway communication.

F. Andrews—In regard to transportation, I consider $7 a ton is an excessive charge. It has been sent from San Francisco to New York for that rate. We are at the mercy of one railway at Sudbury; another would help mining considerably. At the mercy of one railway.

H. P. McIntosh—The construction of railways for the opening up of mineral regions should be the object of special and most generous encouragement. This policy should apply to both Provincial and Dominion governments, and if it were done Canadian industries would receive a healthy impetus that would be a surprise to your most sanguine friends. On the other hand, if the present policy continues the present state of affairs will continue. With such spasmodic efforts as have been made by you to buck against it, it has been the inevitable result that has followed every one of the enterprises. Nature has done her part. Will your governments do anything to add to the talent temporarily entrusted to your keeping? The answer to this question is all that there is between what now is and what ought to be. The shipping facilities are all over the Canadian Pacific railway. The maximum rate for the output of these mines and for the coke and coal which should be taken into them was given to us by the president of that company, Mr. VanHorne, before any shipments were made, and were quite satisfactory. It is only justice to Mr. VanHorne to say that from the first he has manifested a great interest in the success of the enterprise, and has not only expressed a willingness to do, but has already done much to aid in its efforts to develop the property. Railway communication should be generously encouraged. Favorable railway rates.

A. J. Cattanach—I think it is extremely important that the mineral districts of the province should be opened up by railways and colonisation roads, and I believe that the province at large would derive great advantages therefrom. Take the case of the suggested James' Bay railway; that line will go through a very interesting country and a large area of government lands, besides bringing us into connection with the waters of the Hudson bay. In reference to the district south and west of Port Arthur, I think it is a matter of great importance to the whole province that a railway should be built from Port Arthur to meet the Iron Range road from Duluth; there is sufficient mineral development there to justify it. From Port Arthur to Whitefish lake there is ample development to justify a railway independently of anything beyond; the distance to Whitefish lake is 48 miles. But I think in the interest of the country the road should branch into the iron country near the boundary line on our side. I cannot say whether it is a continuation of the Vermilion range, but I believe the ore to be immense in quantity and good in quality. I believe that the development of that range would largely promote the trade of the country and open up that particular district. I think it would be well to strike from Whitefish lake southerly towards this range and westerly towards Rainy river, passing the Huronian range. Both roads might use the same line from Port Arthur to Whitefish lake; but if only one of them can be built just now I think it should be the Port Arthur, Duluth and Western railway. I understand that the Iron Range railway, as it is called, was built in 1887 from Duluth into the iron range of northern Minnesota. The state of Minnesota largely subsidised the railway by giving a bonus or aid of 10,000 acres per mile. The iron range was the objective point of the road. If the road were built on our side the ore would probably be transported to Port Arthur or Fort William and shipped there. The Iron Range railway transported to Duluth or Two Harbors and shipped from there last year about 350,000 tons, I am informed. The principal trade of Duluth to-day is iron and grain. I have heard from contractors who have been examining the line of the Port Arthur and Duluth road lately that they think the trade of the silver mines along this line would be enough of itself to warrant the building of the road; and I know that with moderate assistance from the provincial legislature they would undertake the risk of construction. A railway to the west of Thunder bay would open up the iron range, and by so doing would create a large trade. It would open up the Shebandowan country, which is a very important country as far as gold is concerned. I understand from good judges, practical as well as scientific, that the rock there is the true gold-bearing rock. I sold the 160 acres on which the Huronian mine is located for $50,000 cash for the owners, and I understand the present owners have spent between $100,000 and $150,000 upon it. Everything is ready to go on with the work, but the means of communication are so bad that it practically prevents work at all. It costs about $70 a ton to get stuff in, and that renders the expense so high that nothing but very high grade ore can stand it. Railways and roads are what the country requires. In 1877 the Ontario legislature passed an act called the Railway Land Subsidy act which recites that it would be to the interest of the province at large to have colonisation railways through the unsettled lands, and it provides a scheme for aiding those rail- The mineral districts should be opened up by railways and colonisation roads. A railway to develop the silver and iron wealth of the lake Superior country. The Minnesota Iron Range railway. The Shebandowan country. Land grants for colonisation railways.

ways by means of land grants. The land grants are not to be given to the railways, but are set apart by the government on either side of the railway ; the government is to sell the land at not less than $2 an acre as it may think proper, and after paying the expenses connected with the sale of the lands, to pay over so much of the proceeds as the legislature may choose to allot for the building of any particular railway. If there is a surplus it belongs to the government, and the government does not give up the control of the lands. Thus, if the Ontario legislature subsidised a line to the extent of $3,200 a mile under that act, the government could appropriate as much as 10,000 acres on each side of the road for every mile. The government would sell the land itself and after deducting the expenses would give the railway company $3,200 a mile, and if there was a surplus beyond that it would go into the provincial treasury. If they could not sell the land there would be no obligation on the part of the government to the railway. That would help railways, but of course money would be the most serviceable of all ; people do not know much about those lands and would be doubtful about their being good. But I think the government should give a liberal money bonus to the Port Arthur and Duluth road as it is a comparatively short line. The Dominion government has given it $3,200 a mile ; and even with that the company has not been able to secure the necessary funds. Nothing would so open up the country as the building of railways, and if any part of the country was not worth opening up then we would know it. The miners would have to get their supplies of all kinds as well as machinery from the older sections in the beginning, and in addition other industries would spring up. I am looking upon the matter as if it were the case of a man who owned an immense tract of country. It would be to his advantage to do something towards opening it up ; and if he could get any person to build him a railway for half of its cost he would be a gainer, as his property would be improved at the expense of others.

Money subsidies preferred.

E. B. Borron—Too much is frequently expected from the government in the way of direct aid to our various industries. The richness of our mineral deposits cannot be increased by act of parliament ; nor if the produce of our mines exceed our own consumption can the government add anything to the price of our mineral products. Mining may be assisted, and in some districts called into existence, by the construction of railways, or other cheap means of transportation. When the mineral resources of any part of the province have been proved to be such as to justify the expenditure, the best way to promote the prosperity of mines is by aiding in the construction of railways ; but the railways in consideration of the aid should be bound to transport the products of the mine, forest and field at a certain specified tariff. The rate should not be more than one cent a ton per mile on ores, clays, lignite, building stone, etc. It is only by aiding in the construction of railways, by liberal land laws and by furnishing thoroughly reliable information that the provincial government can assist the capitalists. The extension of railways has opened up mines in all parts of the world, with the result that the prices of every description of ore or metal has fallen greatly in the last twenty or thirty years. The prices of iron, copper, zinc and tin are not more than from one-half to two-thirds what they were thirty years ago.

Where mining railways ought to be aided by the government.

Railway extension has cheapened minerals.

H. S. Howland—I think it would be a good policy to give lands to railways so as to open up the country. If there is no probability of iron smelting works being erected or anything being done with the ore there would be nothing for the railway and perhaps it would be better to wait. But where there is a prospect of shipping the ores or smelting them it would be to the interests of all to open up the country.

Land subsidy for railway construction.

MINERAL PRODUCTION OF CANADA IN 1886 AND 1887.

TABLE I.—Mineral production of Canada by quantities and values for the years 1886 and 1887, as compiled from the Geological Survey reports.

Product.	1886.		1887.	
	Quantity.	Value.	Quantity.	Value.
Antimony ore ....tons.	665	$31,490	584	$30,860
Arsenic.......................... "	120	5,460	30	1,200
Asbestos .... "	3,458	206,251	4,619	226,976
Barytes... .... "	3,864	19,270	400	2,400
Brick ....m.	139,345	873,600	181,581*	986,689
Building stone.............cub. yds.	165,777	642,509	262,592*	552,267
Cement............... ......bbl.	....	....	69,843	81,909
Charcoal ....bush.	901,500	54,000	1,610,900	88,823
Chromic iron ore.............tons.	60	945	38	570
Coal.......................... "	2,091,976	4,017,225	2,368,891	4,758,590
Coke.......................... "	35,396	101,940	40,428	135,951
Copper ....lb.	3,505,000	354,000	3,260,424	342,345
Fertiliser.....................tons.	....	....	498*	25,943
Flagstone ....sq. ft.	70,000	7,875	116,000*	11,600
Gold ....oz.	76,879	1,330,442	66,270	1,178,637
Granite ....tons.	6,062	63,309	21,217	142,506
Graphite .... "	500	4,000	300	2,400
Grindstone .... "	4,020	46,545	5,292	64,008
Gypsum......... .... "	162,000	178,742	154,008	157,277
Iron... .... "	....	....	31,527*	1,087,728
Iron ore .... "	69,708	126,982	76,330	146,197
Lead, (fine, contained in ore)..lb.	....	....	204,800	9,216
Lime ....bush.	1,535,950	283,755	2,269,087*	394,859
Limestone for iron flux........tons.	....	....	17,171	17,500
Manganese ore............... "	1,789	41,499	1,245	43,658
Marble and serpentine .... "	501	9,900	242*	6,224
Mica...........................lb.	20,361	29,008	22,083	29,816
Mineral paint ....tons.	....	....	100*	1,500
Miscellaneous clay products.........	....	112,910	....	182,150*
Moulding sand ....tons.	....	....	160*	800
Ochre .... "	350	2,350	385	2,233
Petroleum ....(bbls. of 35 imp. gals.)	486,441	437,797	763,933†	595,868
Phosphate...................tons.	20,495	304,338	23,690	319,815
Pig iron....................... "	22,192*	237,768	24,827	366,192
Platinum ....oz.	....	....	1,400	5,600
Pyrites..................... tons.	42,906	193,077	38,043	171,194
Salt.......................... "	62,359	227,195	60,173	166,394
Silver	....	209,090	....	349,330
Slate ....tons.	5,345	64,675	7,357	89,000
Soapstone .... "	50	400	100	800
Steel .... "	....	....	7,326	331,199
Sulphuric acid................lb.	....	....	5,476,950	70,609
Tile ....m.	12,416	142,617	14,658*	230,068
Whiting......................tons.	....	600	75	600
Estimated other products .....about	....	167,797	....	1,610,499
Total......................abt.	....	$10,529,361	....	$15,000,000

* Incomplete. † The total given by the direct returns from the refineries was finally adopted as the most correct.

MINERAL EXPORTS OF CANADA.

TABLE II.—Showing by quantities and values the exports of minerals the produce of Canada to Great Britain, the United States and other countries for the seven fiscal years 1881-7.

Minerals.		1881.	1882.	1883.	1884.	1885.	1886.	1887.
Coal:								
Great Britain....	tons	4,603	6,120	4,030	14,950	23,784	29,237	29,775
	$	10,062	18,825	13,265	43,026	65,971	76,304	74,245
United States...	tons	334,573	308,335	302,803	340,670	355,696	362,553	404,042
	$	953,301	824,915	790,614	940,890	1,178,799	1,127,677	1,252,867
Other countries ..	tons	80,879	106,856	123,248	96,011	100,226	101,718	93,187
	$	159,728	234,964	283,532	217,256	223,396	212,179	195,160
Totals...........	tons	420,055	421,311	430,081	451,631	479,706	493,508	527,004
	$	1,123,091	1,078,704	1,087,411	1,201,172	1,468,166	1,416,160	1,522,272
Gold bearing quartz:								
Great Britain..	$	767	....	....	....	....	450	....
United States	$	766,551	930,151	911,383	952,131	999,007	1,210,414	1,017,401
Totals..............	$	767,318	930,151	911,383	952,131	999,007	1,210,864	1,017,401
Gypsum, crude:								
United States ...	tons	130,961	130,062	154,809	155,851	116,415	106,737	148,325
	$	119,399	127,139	151,844	160,607	120,046	112,271	165,497
Other countries..	tons	....	....	....	....	....	500	208
	$	....	....	....	....	....	2,465	1,017
Totals...........	tons	130,961	130,062	154,809	155,851	116,415	107,237	148,533
	$	119,399	127,139	151,844	160,607	120,046	114,736	166,514
Oils, mineral, coal, etc.:								
United States...	gals	1,615	....	....	325,549	953,996	251,450	308,734
	$	446	....	....	7,066	27,136	27,742	10,795
Other countries..	gals	841	662	1,422	2,014	970	8,999	1,933
	$	185	136	368	480	167	3,215	356
Totals...........	gals	2,456	662	1,422	327,563	954,966	260,449	310,667
	$	631	136	368	7,546	27,303	30,957	11,151
Ore—antimony:								
Great Britain....	tons	....	....	....	124	717	901	174
	$	....	....	....	4,605	32,200	35,320	10,910
United States...	tons	46	130	368	8	3	2	40
	$	3,921	4,733	11,842	250	1,500	3,000	1,200
Totals	tons	46	130	368	132	720	903	214
	$	3,921	4,733	11,842	4,855	33,700	38,320	12,110
Ore—copper:								
Great Britain....	tons	322	273	236	99	25	....	8
	$	12,045	13,598	10,890	3,860	940	....	535
United States...	tons	19,480	44,471	4,166	1,578	1,232	5,224	5,259
	$	138,367	125,647	139,589	210,184	245,290	291,397	181,010
Totals	tons	19,802	44,744	4,402	1,677	1,257	5,224	5,267
	$	150,412	139,245	150,479	214,044	246,230	291,397	181,545
Ore—iron:								
Great Britain....	tons	....	....	309	....	....	....	2
	$	....	....	4,738	....	....	....	10
United States ...	tons	44,677	43,835	44,635	25,308	54,367	7,542	23,385
	$	114,850	135,463	134,037	66,549	132,074	23,039	71,934
Totals	tons	44,677	43,835	44,944	25,308	54,367	7,542	23,387
	$	114,850	135,463	138,775	66,549	132,074	23,039	71,944
Ore—manganese:								
Great Britain...	tons	1,146	766	769	436	446	1,640	723
	$	16,819	11,255	11,414	7,118	7,816	29,853	12,896
United States...	tons	482	659	425	449	302	281	863
	$	14,824	26,230	18,003	8,733	14,974	13,001	47,266
Other countries..	tons	473	....	....	....	....	153	....
	$	7,095	....	....	....	....	2,754	....
Totals	tons	2,101	1,425	1,194	885	748	2,074	1,586
	$	38,738	37,485	29,417	15,851	22,790	45,608	60,162

MINERAL EXPORTS OF CANADA.

TABLE II.—Showing by quantities and values the exports of minerals, etc.—*Concluded.*

Minerals.		1881.	1882.	1883.	1884.	1885.	1886.	1887.
Ore—silver:								
Great Britain ...	tons	....	....	78	....	....	....	18
	$	3,000	5	200	20	....	3	8,450
United States...	tons	....	....	22	37	31	81	22
	$	31,494	15,105	14,000	12,900	7,539	25,134	16,487
Totals..........	tons	....	....	100	37	31	81	40
	$	34,494	15,110	14,200	12,920	7,539	25,137	24,937
Phosphate:								
Great Britain ...	tons	13,199	13,197	12,263	21,328	16,878	23,718	20,465
	$	210,364	258,391	255,816	451,092	327,508	407,314	360,313
United States...	tons	2,402	2,080	220	32	745	532	733
	$	29,129	28,976	2,400	250	8,980	6,817	6,223
Other countries..	tons	....	1,904	1,995	111	1,361	1,724	1,605
	$	....	40,300	44,500	1,980	25,800	17,820	29,913
Totals	tons	15,601	17,181	14,478	21,471	18,984	25,974	22,803
	$	239,493	327,667	302,716	453,322	362,288	431,951	396,449
Salt:								
United States...	bus.	253,555	381,476	197,185	181,742	107,523	384,283	106,385
	$	39,566	36,418	17,511	17,408	12,326	26,714	9,418
Other countries..	bus.	....	....	....	....	....	210	258
	$	....	....	....	....	....	35	45
Totals..........	bus.	253,555	381,476	197,185	181,742	107,523	384,493	106,643
	$	39,566	36,418	17,511	17,408	12,326	26,749	9,463
Sand and gravel:								
United States...	tons	55,860	54,593	63,426	61,575	90,015	102,795	135,627
	$	12,511	13,789	17,755	14,152	23,590	23,195	23,207
Slate:								
United States...	tons	....	....	148	864	353	260	26
	$	....	....	3,043	11,445	4,210	4,256	420
Other countries..	tons	....	420	....	....	24	22	22
	$	....	8,100	....	....	432	296	880
Totals..........	tons	....	420	148	864	377	282	48
	$	....	8,100	3,043	11,445	4,642	4,552	1,300
Stone and marble unwrought:								
Great Britain...	tons	....	5	....	3	....	....	....
	$	....	3	....	6	....	....	....
United States...	tons	28,176	39,178	26,412	12,926	15,724	14,850	12,173
	$	81,456	83,830	72,779	52,369	52,155	59,888	65,300
Other countries..	tons	13	156	166	25	12	409	32
	$	468	544	589	103	51	2,062	301
Totals..........	tons	28,189	39,339	26,578	12,954	15,736	15,259	12,205
	$	81,924	84,377	73,368	52,478	52,206	61,950	65,601
Other articles:								
Great Britain.	$	595	9,379	13,471	9,945	50,973	40,588	10,363
United States.........	$	40,714	65,625	47,251	50,567	70,892	161,151	216,406
Other countries........	$	172	52	52	2,100	5,765	4,793	15,134
Totals	$	41,481	75,056	60,774	62,612	127,630	206,532	241,903
Total export values:								
Great Britain.........	$	253,652	311,456	443,831	519,672	485,408	589,832	477,722
United States	$	2,346,529	2,418,021	2,198,014	2,505,501	2,898,518	3,115,696	3,085,431
Other countries.......	$	167,648	284,096	329,041	222,819	255,611	245,619	242,796
Totals	$	2,767,829	3,013,573	2,970,886	3,247,092	3,639,537	3,951,147	3,805,959

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE III.—Showing by quantities the articles of manufactures of iron and steel imported into the Dominion of Canada from Great Britain, the United States and all other countries, classified as dutiable and free, for the seven fiscal years 1881-7.

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Anchors:		cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Great Britain........	F	6,072	5,858	10,254	5,889	5,621	3,385	2,422
United States	"	423	530	1,032	866	605	198	684
Other countries......	"	....	92	8	18	21	....	11
Totals............	"	6,495	6,480	11,294	6,773	6,247	3,583	3,117
Anvils:								
Great Britain........	D	898	1,091	2,873	1,732	1,286	970	886
United States	"	40	133	113	94	324	28	57
Other countries......	"	....	....	....	67	2	....	....
Totals............	"	938	1,224	2,986	1,893	1,612	998	943
Band and hoop iron:								
Great Britain......	D	48,449	69,810	68,327	72,261	60,242	62,858	99,636
	F	....	....	....	1	....	....	....
United States......	D	2,812	4,019	1,514	4,705	2,468	3,764	4,048
	F	....	....	....	55	54	58	121
Other countries......	D	....	31	....	172	334	....	....
Totals..........	"	51,261	73,860	69,841	77,138	63,044	66,622	103,684
	F	....	....	....	56	54	58	121
Bars and ingots:								
Great Britain	D	568,977	857,238	859,556	756,544	637,169	657,058	967,286
	F	173,105	208,274	318,964	....	....	....	....
United States......	D	16,484	16,725	21,893	39,293	34,079	32,843	34,827
	F	33,230	112,329	46,574	....	....	....	....
Other countries ...	D	15,821	17,531	19,547	12,848	15,877	17,066	17,478
	F	2,891	7,779	6,161	....	....	....	....
Totals..........	D	601,282	891,494	900,996	808,685	687,125	706,967	1,019,591
	F	*209,226	*328,382	*371,699	....	....	....	....
Boiler plate:								
Great Britain........	D	55,430	79,855	81,312	82,594	64,136	103,831	106,117
United States	"	10,594	8,856	7,163	8,370	7,400	8,271	5,993
Other countries......	"	319	2,337	3,294	1,023	1,588	2,426	939
Totals............	"	66,343	91,048	91,769	91,987	73,124	114,528	113,049
Bolts, nuts and rivets:								
Great Britain......	D	....	....	....	....	....	....	4,015
	F	....	1,411	1,106	15,536	2,540	4,866	....
United States......	D	....	....	....	....	....	....	3,354
	F	....	....	2,045	1,696	368	363	176
Totals..........	D	....	....	....	....	....	....	7,369
	F	....	1,411	3,151	17,232	2,908	5,229	176
Canada plates:								
Great Britain.	D	65,944	60,663	68,903	78,689	106,796	104,564	112,670
United States........	"	....	129	139	966	166	398	172
Totals............	"	65,944	60,792	69,042	79,655	106,962	104,962	112,842
Chains:								
Great Britain...	D	47,035	47,781	73,600	44,815	41,230	39,570	32,971
United States	"	1,205	3,356	2,436	2,203	1,095	2,173	2,098
Other countries......	"	190	467	394	525	330	582	703
Totals............	"	48,430	51,604	76,430	47,543	42,655	42,325	35,772
Iron bridges and structural iron work:								
Great Britain......	D	12,508	14,392	7,850	25,328	2,538	....	36,944
	F	....	....	....	....	....	6,192	....
United States......	D	71,658	35,272	29,671	69,786	8,284	2,043	9,835
	F	....	....	....	58,630	19,900	2,142	692

Including sheet and coil steel.

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE III.—Showing by quantities the articles of manufactures of iron and steel imported, etc.—*Continued*

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Iron bridges, etc.—*Continued:*		cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Other countries......	D	....	....	....	5,159	49	....	7,872
Totals..........	D	84,166	49,664	37,521	100,273	10,871	2,043	54,651
	F	....	....	....	58,630	19,900	8,334	692
Iron in slabs, blooms, loops or billets:								
Great Britain........	D	111,652	203,882	256,510	250,295	311,492	272,418	511,073
United States........	"	14	6	2,129	2,015	264	....	11,227
Other countries......	"	....	....	....	....	573	898	553
Totals............	"	111,666	203,888	258,639	252,310	312,329	273,316	522,853
Locomotive tires of steel:								
Great Britain......	D	5,610	4,662	3,798	5,520	3,144	4,562	4,790
	F	....	....	....	....	....	....	2,081
United States	D	637	383	1,099	787	199	877	959
	F	....	....	....	....	....	....	192
Other countries....	D	1,097	3,898	2,741	2,944	2,278	4,107	7,977
	F	....	....	....	....	....	....	2,329
Totals..........	D	7,344	8,943	7,638	9,251	5,621	9,546	13,726
	F	....	....	....	....	....	....	4,602
Nails, spikes, etc.:								
Great Britain......	D	16,665	21,424	30,108	20,909	5,367	17,500	23,987
	F	....	....	....	7,778	3,571	4,416	....
United States......	D	2,799	4,372	2,544	2,961	4,796	3,571	3,846
	F	....	1,286	....	....	....	446	393
Other countries......	D	492	615	1,186	842	775	1,404	3,819
Totals..........	D	19,956	26,411	33,838	24,712	10,938	22,475	31,652
	*F	....	1,286	....	7,778	3,571	4,862	393
Pig iron:								
Great Britain........	D	658,880	974,240	1,307,220	815,100	695,460	708,460	803,660
United States........	"	213,160	294,380	242,640	228,360	170,160	201,120	200,440
Other countries......	"	560	....	....	220	2,340	3,380	180
Totals............	"	872,600	1,268,620	1,549,860	1,043,680	867,960	912,960	1,004,280
Railway iron (rails, fish plates, etc.):								
Great Britain......	D	3,597	4,074	5,334	8,093	24,466	38,512	158,764
	F	73,797	97,669	67,001	153,653	31,743	23,280	....
United States......	D	2,136	11,579	8,831	44,923	943	1,272	5,379
	F	1,096	2,359	2,750	....	2,934	49,322	695
Totals..........	D	5,733	15,653	14,165	53,016	25,409	39,784	164,143
	F	74,893	100,028	69,751	153,653	34,677	72,602	695
Rolled beams, channels and angle or T iron:								
Great Britain......	D	20,824	38,004	49,766	59,521	37,349	60,001	104,357
	F	....	....	269	528	431	858	15,481
United States.....	D	6,106	2,110	9,705	7,847	8,204	9,691	8,590
	F	....	....	....	179	223	105	1,827
Other countries......	D	684	1,807	1,133	15,147	8,728	9,879	10,914
Totals..........	"	27,614	41,921	60,604	82,515	54,281	79,571	123,861
	F	....	....	269	707	654	963	17,308
Scrap:								
Great Britain......	D	1,490	4,920	2,840	....	....	....	1,140
	F	....	....	220	56,154	61,658	172,797	320,202
United States......	D	1,990	10,805	5,700	....	....	....	40
	F	....	....	7,307	3,114	5,160	23,715	13,055
Other countries....	D	8,200	10,820	5,640	....	....	....	400
	F	....	....	341	3,458	4,223	6,508	18,993
Totals	D	11,680	26,545	14,180	....	....	....	1,580
	F	....	....	7,868	62,726	71,041	203,020	352,250

* Railroad spikes.

IMPORTS OF IRON AND STEEL MANUFACTERES.

TABLE III.—Showing by quantities the articles of manufactures of iron and steel imported, etc.—*Concluded.*

Articles	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Sewing machines:		No.	No.	No.	No.	No.	No.	No.
Great Britain	D	4,775	3,584	9,619	2,758	95	54	116
United States	"	9,025	16,488	11,887	9,493	7,768	6,730	8,672
Other countries	"	....	4	13	8	8	17	11
Totals	"	13,800	20,076	21,519	12,259	7,871	6,801	8,799
Sheet iron and steel:		cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Great Britain	D	97,570	116,466	164,931	153,689	145,624	170,395	217,031
	F	....	....	....	2,183	36,979	55,646	17,999
United States	D	4,427	3,378	7,759	7,258	7,359	10,306	14,991
	F	....	....	....	2,259	2,803	3,043	7,050
Other countries	D	....	121	....	42	526	155	1,084
	F	....	....	....	....	1	....	7,448
Totals	D	101,997	119,965	172,690	160,989	153,509	180,856	233,106
	F	....	....	....	4,442	39,783	58,689	32,497
Steel rails:								
Great Britain	F	1,787,068	1,927,120	1,698,637	1,756,995	1,626,542	1,128,921	2,261,263
United States	"	51	352,839	637,882	306,838	300,975	30,062	82,980
Other countries	"	5,879	....	2,405	....	....	....	....
Totals	"	1,792,998	2,279,959	2,338,924	2,063,833	1,927,517	1,158,983	2,344,243
Stoves:		No.	No.	No.	No.	No.	No.	No.
Great Britain	D	16	99	46	60	48	53	48
United States	"	1,068	1,830	4,515	3,769	3,578	1,923	1,618
Other countries	"	....	5	2	....	1	....	1
Totals	"	1,084	1,934	4,563	3,829	3,627	1,976	1,667
Screws:				gross.	gross.	gross.	gross.	
Great Britain	D	....	....	199,986	258,981	422,241	188,766	....
United States	"	....	....	10,401	7,273	9,820	11,140	....
Other countries	"	....	....	6,150	8,593	17,421	1,137	....
Totals	"	....	....	216,537	274,847	449,482	201,043	....
Tubing:				feet.	feet.	feet.	feet.	
Great Britain	D	....	....	4,622,399	3,259,048	3,376,390	3,549,200	....
United States	"	....	....	1,158,450	937,692	764,464	926,189	....
Other countries	"	....	....	303,093	535,399	88,583	850,343	....
Totals	"	....	....	6,083,942	4,732,139	4,229,437	5,325,732	....
Printing presses:		No.	No.	No.	No.	No.	No.	No.
Great Britain	D	21	15	29	21	16	12	20
United States	"	169	252	305	330	293	192	256
Other countries	"	2	5	4	5	2	6	2
Totals	"	192	272	338	356	311	210	278
Tin plate:		cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Great Britain	D	165,160	85,198	....	....	....	....	....
	F	....	83,944	156,278	145,629	177,136	173,787	209,973
United States	D	10,534	9,199	....	....	....	....	....
	F	....	16,811	14,662	8,415	8,148	31,089	16,153
Other countries	D	18	290	....	....	....	....	....
	F	....	....	....	....	28	....	....
Totals	D	175,712	94,687	....	....	....	....	....
	F	....	100,755	170,940	154,044	185,312	204,876	226,126

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE IV.—Showing by values the articles of manufactures of iron and steel imported into the Dominion of Canada from Great Britain, United States and all other countries, classified as dutiable and free, for the seven fiscal years 1881-7.

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Agricultural implements:		$	$	$	$	$	$	$
Great Britain........	D	19,532	21,074	21,298	27,333	14,909	17,344	13,394
United States	"	157,690	279,999	561,698	190,990	158,419	139,775	116,971
Other countries	"	8	7	69	411	313	188	181
Totals..........	"	177,230	301,080	583,065	218,734	173,641	157,307	130,546
Anchors:								
Great Britain........	F	21,724	19,842	30,389	21,667	18,280	9,872	5,988
United States	"	2,169	3,074	7,255	4,090	2,787	1,198	2,590
Other countries	"	....	230	15	36	78	....	34
Totals............	"	23,893	23,146	37,659	25,793	21,145	11,070	8,612
Anvils:								
Great Britain........	D	6,856	7,066	16,164	12,118	4,923	5,551	4,949
United States	"	528	1,146	559	703	1,554	241	434
Other countries......	"	....	....	....	266	12	....	....
Totals............	"	7,384	8,212	16,723	13,087	6,489	5,792	5,383
Band and hoop iron:								
Great Britain......	D	85,570	113,705	113,882	120,214	95,944	91,546	122,797
	F	....	....	....	15	....	....	....
United States	D	10,732	16,047	6,140	9,991	8,015	11,318	10,816
	F	....	....	....	773	700	735	1,428
Other countries......	D	....	179	....	518	1,529	....	....
Totals..........	D	96,302	129,931	120,022	130,723	105,488	102,864	133,613
	F	....	....	....	788	700	735	1,428
Bars and ingots:								
Great Britain	D	841,707	1,243,722	1,308,686	1,282,995	948,356	892,928	1,164,982
	F	567,112	668,406	992,887	....	....	....	....
United States	D	47,480	40,653	61,405	150,496	122,963	101,760	99,521
	F	214,799	199,981	238,914	....	....	....	....
Other countries....	D	37,174	44,235	44,270	28,414	36,044	37,045	31,651
	F	11,418	27,470	20,104	....	....	....	....
Totals..........	D	926,361	1,328,610	1,414,361	1,461,905	1,107,363	1,031,733	1,296,154
	F	*793,329	*895,857	*1,251,905	....	....	....	....
Bedsteads:								
Great Britain........	D	4,778	8,877	11,116	9,258	13,190	14,162	19,246
United States	"	2,348	2,723	5,139	1,970	3,905	2,434	621
Other countries.....	"	....	....	63	....	5	....	19
Totals......	"	7,126	11,600	16,318	11,228	17,100	16,596	19,886
Boiler plate:								
Great Britain........	D	128,846	182,496	203,953	186,615	120,708	163,343	153,085
United States	"	47,549	36,357	35,328	31,771	26,592	20,607	20,705
Other countries.....	"	1,864	11,280	12,973	2,717	4,454	4,702	1,455
Totals...........	"	178,259	230,133	252,254	221,103	151,754	188,652	175,245
Bolts, nuts and rivets:								
Great Britain......	D	39,904	32,544	32,622	24,135	16,969	16,570	12,933
	F	....	5,113	3,110	4,702	2,602	3,238	....

*Including sheet and coil steel.

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE IV.—Showing by values the articles of manufactures of iron and steel imported, etc.—*Continued.*

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
		$	$	$	$	$	$	$
Bolts, etc.—*Con*								
United States	D	48,652	45,405	66,452	36,535	46,638	45,124	24,357
	F	....	....	5,364	3,481	1,030	1,165	478
Other countries	D	37	....	....	11	....	96	....
Totals	"	88,593	77,949	99,074	60,681	63,607	61,790	37,290
	F	....	5,113	8,474	8,183	3,632	4,403	478
Canada plates:								
Great Britain	D	170,772	140,480	160,777	172,774	218,164	186,234	180,305
United States	"	....	728	316	2,653	492	878	619
Totals	"	170,772	141,208	161,093	175,427	218,656	187,112	180,924
Castings and forgings:								
Great Britain	D	74,128	158,072	198,907	239,569	133,606	92,413	215,280
United States	"	257,359	325,266	432,777	406,293	302,243	263,410	282,423
Other countries	"	4,996	2,678	5,437	22,406	12,541	30,684	46,357
Totals	"	336,483	486,016	637,121	668,268	448,390	386,507	544,060
Chains:								
Great Britain	D	138,372	138,155	199,673	130,389	112,365	92,913	79,891
United States	"	5,296	11,184	10,013	8,601	5,826	6,325	8,164
Other countries	"	1,340	3,240	3,050	2,388	1,604	2,679	2,930
Totals	"	145,008	152,579	212,736	141,378	119,795	101,917	90,985
Cutlery:								
Great Britain	D	291,849	424,094	352,850	269,604	209,164	244,189	290,478
United States	"	48,457	77,342	86,363	53,290	50,453	44,834	46,497
Other countries	"	16,679	28,519	26,927	21,235	22,389	30,514	40,133
Totals	"	356,985	529,955	466,140	344,129	282,006	319,537	377,108
Edge tools:								
Great Britain	D	80,543	110,810	108,250	63,405	41,441	43,114	54,935
United States	"	172,897	276,998	345,583	247,005	204,487	216,804	262,765
Other countries	"	5,236	8,672	10,746	8,531	7,183	6,707	8,436
Totals	"	258,676	396,480	464,579	318,941	253,111	266,625	326,136
Engines* and boilers:								
Great Britain	D	2,695	157,811	51,149	21,372	4,706	413	14,116
United States	"	197,320	864,979	994,028	535,900	120,352	208,885	122,710
Other countries	"	50	....	....	....	....	....	559
Totals	"	200,065	1,022,790	1,045,177	557,272	125,058	209,298	137,385
Files and rasps:								
Great Britain	D	57,080	64,994	77,297	59,098	48,702	41,094	38,482
United States	"	6,542	16,319	29,002	31,002	22,615	30,233	35,912
Other countries	"	126	315	42	602	733	353	495
Totals	"	63,748	81,628	106,341	90,702	72,050	71,680	74,889
Firearms:								
Great Britain	D	37,044	45,675	72,710	47,366	47,044	50,301	48,292
United States	"	40,228	81,111	98,407	64,686	68,316	56,262	55,286
Other countries	"	2,078	15,366	17,209	13,438	9,964	14,818	17,323
Totals	"	79,350	142,152	188,326	125,490	125,324	121,381	120,901

*Including locomotives.

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE IV.—Showing by values the articles of manufactures of iron and steel imported, etc.—*Continued.*

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Hardware:		$	$	$	$	$	$	$
Great Britain........	D	106,978	117,071	110,777	89,113	55,285	79,297	110,699
United States	"	408,447	527,786	590,057	437,371	445,098	621,204	723,260
Other countries......	"	7,080	5,257	3,360	4,493	3,948	9,086	12,579
Totals...........	"	522,505	650,114	704,194	530,977	504,331	709,587	846,538
Hollow-ware:								
Great Britain........	D	21,262	27,718	30,267	25,448	20,703	23,889	34,391
United States	"	46,854	69,726	73,683	76,996	73,111	85,399	112,789
Other countries......	"	52	364	1,150	234	624	519	1,680
Totals...........	"	68,168	97,808	105,100	102,678	94,438	109,807	148,860
Horse shoes and shoe nails:								
Great Britain	D	367	418	614	955	1,075	275	....
United States	"	2,558	4,330	5,169	5,730	2,640	3,888	3,547
Totals...........	"	2,925	4,748	5,783	6,685	3,715	4,163	3,547
Iron bridges:								
Great Britain......	D	50,980	46,007	27,810	101,066	11,576	....	80,541
	F	....	....	....	....	....	194,728	....
United States	D	369,430	166,520	134,545	310,057	37,178	8,916	43,201
	F	....	11,515	....	322,579	77,154	9,886	2,082
Other countries......	D	....	....	....	20,161	66	....	16,320
Totals..........	"	420,410	212,527	162,355	431,284	48,820	8,916	140,062
	F	....	11,515	....	322,579	77,154	204,614	2,082
Iron in slabs, blooms, loops or billets:								
Great Britain........	D	111,350	222,010	264,801	259,685	286,776	247,740	412,408
United States	"	24	46	5,017	4,360	246	....	8,916
Other countries	"	....	....	....	....	712	721	274
Totals...........	"	111,374	222,056	269,818	264,045	287,734	248,461	421,598
Locks:								
Great Britain........	D	16,238	19,839	15,868	10,876	11,457	15,506	13,421
United States	"	33,973	62,501	57,033	70,880	64,390	67,022	69,845
Other countries	"	19	36	38	17	....	6	144
Totals...........	"	50,230	82,376	72,939	81,773	75,847	82,534	83,410
Locomotive tires of steel:								
Great Britain......	D	21,205	23,896	18,273	21,927	11,095	20,713	16,357
	F	....	....	....	....	....	....	8,069
United States	D	4,089	2,582	6,829	4,492	926	2,217	4,104
	F	....	....	....	....	....	....	923
Other countries....	D	3,759	18,702	11,898	13,171	9,734	17,208	21,332
	F	....	....	....	....	....	....	10,948
Totals..........	D	29,053	45,180	37,000	39,590	21,755	40,138	41,793
	F	....	....	....	....	....	....	19,940
Machinery:								
Great Britain......	D	254,581	799,348	851,850	259,942	136,996	130,471	222,635
	F	306,443	....	....	175,531	20,734	....	....
United States	D	767,391	1,388,076	1,899,920	1,099,776	780,114	874,393	1,070,970
	F	54,665	....	....	4,645	1,798	....	....
Other countries......	D	546	7,381	5,800	4,921	4,164	1,720	36,028
Totals..........	"	1,022,518	2,194,805	2,757,570	1,364,639	921,274	1,006,584	1,329,633
	F	361,108	....	....	180,176	22,532	....	....

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE IV.—Showing by values the articles of manufactures of iron and steel imported, etc.—*Continued.*

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
		$	$	$	$	$	$	$
Nails, spikes, etc.:								
Great Britain	D	48,721	49,196	74,869	49,265	21,283	48,191	46,518
	F	....	....	....	24,866	9,632	15,938	....
United States	D	17,773	22,330	16,288	18,094	21,796	16,297	17,631
	F	....	3,849	....	....	....	1,500	1,016
Other countries	D	2,203	3,093	4,179	4,530	2,436	4,109	10,802
Totals	D	68,697	74,619	95,336	71,889	45,515	68,597	74,951
	*F	....	3,849	....	24,866	9,632	17,438	1,016
Needles:								
Great Britain	D	37,769	39,685	38,246	33,390	28,917	28,233	32,139
United States	"	16,910	19,137	22,081	19,856	16,903	16,500	18,902
Other countries	"	250	179	680	210	282	273	1,325
Totals	"	54,929	59,001	61,007	53,456	46,102	45,006	52,366
Pig iron:								
Great Britain	D	457,103	633,206	842,234	490,551	394,904	387,052	422,736
United States	"	258,577	389,806	302,515	229,575	176,292	199,450	208,992
Other countries	"	317	....	....	184	1,563	2,067	80
Totals	"	715,997	1,023,012	1,144,749	720,310	572,759	588,569	631,808
Railway iron (rails, fish plates, etc.):								
Great Britain	D	7,836	6,209	8,860	11,571	40,895	51,190	166,684
	F	139,236	155,146	116,181	214,770	52,644	19,306	....
United States	D	7,344	15,326	13,949	40,509	3,329	5,991	8,077
	F	7,278	7,778	7,844	....	6,060	38,894	1,472
Totals	D	15,180	21,535	22,809	52,080	44,224	57,181	174,761
	F	146,514	162,924	124,025	214,770	58,704	58,200	1,472
Rolled beams, channels, and angle or T iron:								
Great Britain	D	38,686	72,344	90,700	97,983	61,441	81,425	141,687
	F	....	....	597	1,472	2,995	1,120	24,997
United States	D	20,235	8,579	30,409	27,357	24,119	21,487	22,372
	F	....	....	....	854	1,364	229	2,499
Other countries	D	1,612	2,929	1,746	21,305	11,367	11,794	14,640
Totals	"	60,533	83,852	122,855	146,645	96,927	114,706	178,699
	F	....	....	597	2,326	4,359	1,349	27,496
Safes, and doors for safes and vaults:								
Great Britain	D	53	149	121	25	53	....	170
United States	"	9,782	20,964	33,226	15,708	20,026	9,046	6,229
Other countries	"	....	....	....	....	50	....	278
Totals	"	9,835	21,113	33,347	15,733	20,129	9,046	6,677
Scales:								
Great Britain	D	3,729	1,746	2,717	2,392	1,718	1,514	1,865
United States	"	42,438	47,617	50,208	42,631	26,791	25,247	24,381
Other countries	"	161	231	457	279	383	589	410
Totals	"	46,328	49,594	53,382	45,302	28,892	27,350	26,656

*Railroad spikes.

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE IV.—Showing by values the articles of manufactures of iron and steel imported, etc.—*Continued.*

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
		$	$	$	$	$	$	$
Scrap:								
Great Britain	D	1,148	5,012	1,802	....	....	....	901
	F	....	....	180	38,518	41,115	137,181	199,228
United States	D	1,818	10,996	3,412	....	....	....	15
	F	....	....	4,300	3,901	3,867	17,507	11,185
Other countries	D	5,841	4,398	2,562	....	....	....	170
	F	....	....	285	1,804	1,293	3,412	9,754
Totals	D	8,807	20,406	7,776	....	....	....	1,086
	F	....	....	4,765	44,223	46,275	158,100	220,167
Screws:								
Great Britain	D	23,295	34,079	27,435	31,082	28,509	18,813	31,192
United States	"	4,101	3,888	3,981	2,857	3,085	3,289	2,890
Other countries	"	4,743	1,086	559	1,223	1,686	575	....
Totals	"	32,139	39,053	31,975	35,162	33,280	22,677	34,082
Sewing machines:								
Great Britain	D	44,408	39,105	95,543	31,534	2,402	1,644	3,064
United States	"	148,929	267,901	227,040	194,479	166,595	145,393	155,572
Other countries	"	....	171	614	219	149	217	310
Totals	"	193,337	307,177	323,197	226,232	169,146	147,254	158,946
Sheet iron and steel:								
Great Britain	D	267,544	323,655	425,824	447,816	375,409	397,907	475,046
	F	....	....	....	22,289	89,947	48,912	83,557
United States	D	21,721	18,981	32,248	32,642	32,428	42,739	52,471
	F	....	....	....	22,892	22,704	26,132	38,922
Other countries	D	....	210	....	88	2,236	383	4,625
	F	....	....	....	....	2	....	8,597
Totals	D	289,265	342,846	458,072	480,546	410,073	441,029	532,142
	F	....	....	....	45,181	112,653	75,044	131,076
Skates:								
Great Britain	D	292	338	1,321	691	142	278	376
United States	"	11,358	3,261	1,467	4,704	35,584	14,824	3,645
Other countries	"	631	1,138	1,779	909	678	697	21,983
Totals	"	12,281	4,737	4,567	6,304	36,404	15,799	26,004
Steel rails:								
Great Britain	F	2,966,958	2,923,063	2,717,034	2,376,391	2,031,137	1,491,926	1,999,081
United States	"	230	608,267	1,294,163	418,544	412,380	93,830	123,645
Other countries	"	9,900	....	5,082	....	....	....	....
Totals	"	2,977,088	3,531,330	4,016,279	2,794,935	2,443,517	1,585,756	2,122,726
Stoves:								
Great Britain	D	322	1,139	688	1,036	423	469	580
United States	"	16,465	23,678	48,339	46,392	28,853	22,522	19,724
Other countries	"	....	97	16	....	73	....	3
Totals	"	16,787	24,914	49,043	47,428	29,349	22,991	20,307
Surgical instruments:								
Great Britain	D	6,270	7,094	11,923	6,875	3,526	5,761	6,287
United States	"	6,816	9,739	10,345	5,558	2,410	3,559	3,315
Other countries	"	1,360	322	2,990	909	728	788	603
Totals	"	14,446	17,155	25,258	13,342	6,664	10,108	10,205

IMPORTS OF IRON AND STEEL MANUFACTURES.

TABLE IV.—Showing by values the articles of manufactures of iron and steel imported, etc.—*Concluded.*

Articles.	Dutiable or Free.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
Tubing:		$	$	$	$	$	$	$
Great Britain........	D	179,681	307,133	315,384	200,355	178,937	165,698	317,078
United States	"	110,597	124,57	164,180	124,148	88,297	94,395	78,334
Other countries......	"	4,796	7,334	29,623	37,695	7,550	40,864	61,289
Totals............	"	295,074	439,041	509,187	362,198	274,784	300,957	456,701
Wire and wirework:								
Great Britain......	D	253,230	318,304	389,176	242,078	179,042	274,914	251,336
	F	47,199	38,429	81,573	79,206	70,539	65,383	55,134
United States	D	130,681	135,071	149,714	113,022	87,740	134,343	160,515
	F	1,193	2,572	8,183	43,004	52,903	67,880	60,135
Other countries....	D	76,677	116,445	59,554	52,656	65,653	99,161	75,689
	F	....	....	1,429	10,274	8,032	11,356	63,270
Totals..........	D	460,588	569,820	598,444	407,756	332,435	508,418	487,540
	F	48,392	41,001	91,185	132,484	131,474	144,619	178,539
Other articles:								
Great Britain......	D	83,465	106,025	121,748	67,629	74,617	59,616	101,925
	F	7,281	8,934	5,868	23,597	11,317	2,582	8,227
United States	D	118,652	142,179	144,358	151,578	129,126	107,439	99,417
	F	....	958	95	2,459	301	1,973	1,239
Other countries....	D	10,679	6,106	9,437	39,633	67,862	14,676	6,448
	F	....	....	....	....	....	....	488
Totals..........	D	212,796	254,310	275,543	258,840	271,605	181,731	207,790
	F	7,281	9,892	5,963	26,056	11,618	4,555	9,954
*Printing presses:								
Great Britain........	D	9,387	5,312	9,203	8,980	8,762	5,776	12,739
United States	"	34,859	79,359	125,229	111,282	119,764	79,878	71,711
Other countries......	"	627	4,710	783	4,187	5,800	3,732	6,724
Totals............	"	44,873	89,381	135,215	124,449	134,326	89,386	91,174
*Tin plate:								
Great Britain......	D	718,551	355,059	....	....	....	....	....
	F	....	355,656	723,024	608,264	705,924	619,971	706,975
United States	D	53,089	43,639	....	....	....	....	....
	F	....	93,045	84,172	37,254	26,788	124,849	60,861
Other countries....	D	66	1,154	....	....	....	....	....
	F	....	....	....	....	100	....	....
Totals..........	D	771,706	399,852	....	....	....	....	....
	F	....	448,701	807,196	645,518	732,812	744,820	767,836
Total imports:								
Great Britain. Dutiable.	....	4,016,189	6,050,301	6,698,185	5,149,530	3,957,372	3,992,711	5,303,201
Free	....	4,055,953	3,818,933	3,947,819	2,983,024	2,350,942	1,990,186	2,384,281
Total ...	....	8,072,142	9,869,234	10,646,004	8,132,554	6,308,314	5,982,897	7,687,482
United States. Dutiable.	....	3,620,041	5,561,851	6,759,223	4,850,658	3,409,947	3,674,450	4,006,915
Rree	....	280,334	837,994	1,566,118	827,222	583,048	260,929	247,614
Total ...	....	3,900,375	6,399,845	8,325,341	5,677,880	3,992,995	3,935,379	4,254,529
Other countries. Dutiable.	....	190,314	289,970	257,228	303,774	278,715	333,239	436,551
Free	....	21,318	27,700	26,915	12,114	9,405	14,768	93,091
Total ...	....	211,632	317,670	284,143	315,888	288,120	348,007	529,642
Totals... Dutiable.	....	7,826,544	11,902,122	13,714,636	10,303,962	7,646,034	8,000,400	9,746,667
Free	....	4,357,605	4,684,627	5,540,852	3,822,360	2,943,395	2,265,883	2,724,986
Total ...	....	12,184,149	16,586,749	19,255,488	14,126,322	10,589,429	10,266,283	12,471,653

*Not included in total imports.

SECTION IV.

MINING LAWS AND REGULATIONS.

The mining industry of Ontario may be said to date its origin from the year 1822, when the late Joseph VanNorman started a blast furnace in the county of Norfolk for the smelting of bog iron ore. Another furnace was erected a little later by Mr. Hayes at Marmora, in the county of Hastings, who obtained from the government for mining and charcoal-making purposes a tract of 14,000 acres in the townships of Marmora and Belmont. But neither of those ventures seems to have awakened interest in mining affairs in the province. The poor fortune of the second one may be said to have deterred enterprise in this field; and for the next twenty years the official records do not give evidence of any activity in the sale of mineral lands, or in search for the discovery of minerals or ores of any kind.

Origin of the mining industry in Ontario.

To the possible existence of a mineral region of some value on the north shore of lake Superior some allusion was made by Mr. Logan in his report on the progress of the Geological Survey of the province in 1843. Mr. Logan himself did not visit the lake Superior country until 1846, but was influenced "by the unprejudiced account regarding the mineral riches of the southern shore furnished to the legislature of Michigan by the late Mr. Douglas Houghton in 1841, in his report on the geological structure of the upper peninsula of the state."* Mr. Houghton had been officially employed for eight years investigating the mineral resources of Michigan, and it was in the prosecution of his duties that he lost his life in 1845. "It is understood," Mr. Logan wrote, "that he had visited the British shores of lake Superior, and considered their mineral character much the same as that of his own side of the water, though I believe he has made no published statement to that effect."

Mineral resources of the upper lake region.

Attention having been called to the possible mineral resources of our upper lake region in this way, applications began to be made to the government for license to explore the lands on the north and east shores of lake Superior and on the north shore of lake Huron, the pioneer in this enterprise being Hon. John Prince, who applied for the Spar island tract on 1st July, 1845. Thirty-one applications were made in that year, thirty of which were for locations on lake Superior. In 1846 the number increased to one hundred on lake Superior and thirty-three on lake Huron; but as the terms of possession were not settled until late in this year, when the management of mineral lands was transferred from the provincial secretary's office to the department of crown lands, a large number of the claims were suffered to lapse through failure to comply with the terms.

Licenses to explore the region.

* Upper Canada Sessional Papers, 1847, Appendix A A A. See also Mr. Logan's Report of Progress for 1843, S. P. 1844-5, Appendix W.

Sales of mineral lands.

The records of the department show that the extent of public land in the province sold for mining purposes during the past forty-four years (from 1845 to the close of 1888) was 709,335 acres, for which the treasury has received $810,955, being an average of 61⅓ cents per acre in the period before Confederation and $1.35½ per acre in the period since. The first regulations fixed the limit of a location at five miles in length by two in breadth, or 6,400 acres, under which the Montreal company acquired 107,156 acres at 42½ cents per acre, and the Quebec and Lake Superior company 19,200 acres at 80 cents per acre.

In dealing with the subject of our mining laws it is proposed, first, to refer to the opinions of witnesses upon their operation and the various suggestions for their amendment; secondly, to make a comparative study of the laws of Ontario and other countries; and thirdly, in light of the criticism and comparison, to indicate some changes which seem to be desirable in our own laws for the greater development and prosperity of the mining industry.

OPINIONS OF WITNESSES.

The general criticism.

I. The mining laws of the province have been variously criticised by a large number of persons whose testimony has been taken by the Commission. By a few they are regarded as being well suited to the necessities of a substantial industry; but by the majority they are thought to stand in the way of exploration and discovery, to favor the moneyed man at the expense of the prospector, and to facilitate the locking up of large areas for speculative ends.

Applications to purchase.

Applications to purchase land under the mining act are required to be made direct to the department, accompanied by the purchase money and the affidavits of at least two credible witnesses showing that the land is unoccupied and unimproved (except by or for the applicant), and that there is no adverse claim to his on the ground of occupation, improvements or otherwise. It is claimed that the interests of explorers and intending purchasers would be better served were the applications made to local agencies and offices, as in the case of other public lands. At such offices prospectors could be supplied with maps of the territory to be explored and learn what lands are already taken up, besides being able to file claims promptly. It is also suggested that officers with larger powers might be placed at two or three of the principal agencies who could deal on the spot with questions of title and other matters, thus saving a great deal of trouble and preventing future litigation. They might be vested in part with the authority of inspectors of mining divisions, without setting in motion the whole machinery of the mining division system.

Mineral lands and mining locations.

The mining act provides that any crown lands supposed to contain minerals may be sold as mining lands, and that where situate in unsurveyed territory or in townships surveyed into sections they shall be sold in blocks called mining locations. In the opinion of one witness lands should not be taken up as mineral lands till the applicant has made an affidavit that he has found mineral upon them and has produced specimens; a second says that no land should be sold as mining land unless a vein or other workable deposit has been found upon it; and a third thinks it would be a wise provision

to prevent the taking up of mineral land till mineral is shown to exist upon it. By adopting this provision it is thought that the mineral-bearing districts of the country would be more thoroughly explored, and that less extensive areas would pass into the hands of speculators who buy up tracts on the strength of discoveries made in the locality. One witness states that the whole of Denison township, in which the Vermilion gold and copper mines are situated, was bought up by parties who were never on the ground, and who knew nothing of it except the reported discovery on the Vermilion location.

Extent and number of mining locations.

Concerning the extent of locations, and the number which one individual or company may acquire, there is some diversity of opinion. The mining act provides that in the territory north or north-west of the Mattawan and French rivers and Nipissing lake, including the territory bordering on lakes Huron and Superior and the river St. Mary, a mining location shall consist of 80, 160 or 320 acres, while in all other unsurveyed lands it shall be as may be defined by order in council; but the act does not limit the number of locations which one party or company may acquire by purchase from the crown. The opinions of the various witnesses may be summarised as follows: (1) The prospector should be allowed to take up a small quantity of land, say 10 or 12 acres, instead of being compelled to purchase 80 or 160 acres. (2) In the case of iron more land should be allowed, as more is required for works, fuel, etc. If the law compelled owners of properties to work them the holding of large tracts would be less objectionable. (3) The size of a copper claim should be about 80 acres, but for gold and silver it should be 100 by 200 feet. (4) For copper and iron the claims should be from 160 to 320 acres. (5) To carry on mining works like those of the Canada Copper company it is a necessity to have large quantities of land. (6) The taking up of large blocks of land has a tendency to prevent development and keep out *bona fide* miners. A quarter section would be a fair limit, but for wood supplies it ought not to be less than 400 acres. (7) A single location should be forty chains on the course of the vein, and one man should not be allowed to hold more than one claim. (8) The claim should be about half a mile on the vein, and 200 or 300 feet wide. (9) To work a copper mine takes a great amount of capital, and therefore a large quantity of land is necessary in order to be able to do anything; but it is not in the interest of the country that large areas of land should be tied up by one company. (10) The location should be measured on the length of the vein, say about 1500 feet, and the discoverer should be allowed to take two claims adjoining each other. (11) It might be well that a man should be allowed to take 40 acres, if he did not wish to take more, but 80 acres at $2 an acre is a very small matter. (12) A length of 200 feet on the vein is sufficient for a gold mine, and a claim should not be more than 300 feet on the lode; but a man might purchase as much as he liked afterwards, providing a certain quantity of work was done on each claim. (13) The location should be about 80 acres, laid out as now, and the sale of large blocks should not be allowed, except perhaps in the case of iron. (14) The quantity of land sold to one party should be limited, or the tax should be increased so as to force those holding on speculation to sell or develop their property. (15) The selling of large blocks passes the land

A variety of opinions.

into the hands of speculators, but the limit should depend on the quantity of land that is going to be worked. The area would not so much matter if the conditions for working it bore some relation to its extent. For copper, galena, iron and other minerals about 160 acres is sufficient; for gold and silver a less area is required, but purchasers should have enough for the necessary buildings, timber, roads, etc. (16) The limit would have to be fixed by circumstances, but it is not right that one person should be allowed to buy up a whole section of the country. If a man finds a vein, and it turns out to be richer farther on, he should have the the right to pre-empt another claim. (17) If the area which could be taken by one party was limited the country would be more thoroughly prospected than it now is, especially should successful development ensue in the district. (18) The sale of large blocks has not retarded development or hindered prospectors, and on the whole it has resulted in more good than harm; but while a limit ought not to be put on the extent of locations, there should be provisions as to development. One of the reasons for wishing to have large properties is, that they improve the chances of getting money to work the mines. (19) Capital is very hard to get to develop mining properties, and it is most important to do all possible to induce investment. Restriction of areas and compulsory work would lead to evasion. The gentlemen whose views are given in the last two statements have had considerable experience in procuring capital for investment in mining properties.

Survey of locations.

The act requires that in unsurveyed territory each mining location shall be surveyed by a provincial land surveyor, and be connected with some known point in previous surveys or with some other known point or boundary at the cost of the applicant, and that each person applying for a tract shall furnish the department with the surveyor's plan, field notes and description, showing a survey in accordance with the act and to the satisfaction of the commissioner. It is stated by witnesses that the costs of a connecting line are in some cases heavy, and that it is not fair to make a pioneer prospector pay for running this line when others may benefit by tying on to him. Among the suggestions are, that in mining districts the government should lay out the country in blocks, as in the North-west territories, or run north and south and east and west lines, that townships should be surveyed as they are prospected, and that where a prospector locates six miles from a surveyed township he should be allowed to stake his claim. It is thought by others that all surveys of locations should be made by the government, as it is often a hardship on the poor man to get his location laid out. Several witnesses also suggest that iron pickets should be put down in making surveys, as wooden ones are frequently destroyed by fires, thus making a new survey necessary at the cost of the private owner.

Suggestions.

Protection for prospectors.

Prospectors are protected in their rights by the regulations of the department governing applications to purchase; but it is stated that in some cases claims are jumped, and that in others, through the inability of a poor man to make cash payment for the whole purchase, his discovery goes to some more fortunate man. The prospectors themselves are unanimous in the opinion that a reasonable time ought to be allowed a discoverer to pay for

his location before it is disposed of to any other applicant. It does not appear, however, that the discoverer is often wronged through failure of the regulations of the department to protect him, or that the jumping of claims is more than an occasional occurrence, especially where it can be shown that a claim has been established by occupation or improvement. Still it is held to be necessary that the prospector should be carefully protected in his rights, for "capital will not explore."

The right to stake out claims is only permissible under the act where a mining division has been established, and the extent of a claim for one person is limited to 200 feet along the vein or lode by 100 feet on each side thereof. Witnesses are generally of opinion that a prospector should be allowed to stake a claim on crown land in any part of the country and obtain his patent at the end of four or five years, on condition of performing a specific amount of work yearly, measured by value or days' labor, the latter preferred as being less favorable to the practice of fraud. Several witneses, however, would make the plan of staking claims liberal enough to allow the prospector to take 40 acres or more, on or off the vein. One witness, Francis Andrews of Sudbury, would fix the limit at 80 to 160 acres, for the reason that he thinks the occurrence of minerals in that district is not favorable for the staking of claims on the vein; while another, Mr. Dawson of Port Arthur, does not believe that the plan would work well in his district, where quartz mining prevails. The plan is favored chiefly because it is thought that it would give effectual protection to the prospector.

Right of staking out claims.

Mining lands in the Huron and Ottawa territory are sold at one dollar per acre, and in the northern and north-western territory at two dollars per acre, cash. Prospectors regard this rule as a hardship, and would prefer a time allowance. One or two witnesses are of opinion that the service of an explorer should entitle him to a free grant of one location, as few of them are possessed of the means to pay; another thinks it is the duty of the government to get the best price for the land; and others suggest that all discoveries of mining land be reported to the department, examined by experts and sold by auction, the same as timber limits, thus securing to the country the benefit of the speculative value. Still another suggestion is, that the discoverer might be allowed to hold the land upon payment of ten cents an acre yearly, till he is in a position to purchase it and take out the patent.

Price of mineral lands, and terms of sale.

Under the mining division system any person holding a license is allowed to mine a claim one year upon payment of a fee of five dollars, with a right of renewal of the license. This is practically the same as the leasing system, but the latter does not seem to be regarded with favor. One witness says licensing has proved altogether a failure in this country, but another thinks it might work well if the land was leased at such a rental that holders would have to mine it or throw it up. Only one witness favors leasing outright, requiring development work for a certain time as a condition precedent; then giving a lease for twenty-five years at a royalty, with the option of renewal for a like term.

The licensing system.

By the mining act of 1869 all royalties reserved or made payable on minerals or ores found upon patented lands were abandoned, both as to the

Royalties.

past and the future, and it was declared that no reservation or exception of gold, silver, iron, copper or other minerals should be inserted thenceforth in any patent from the crown granting lands in the province sold as mining lands. Exception, however, is made of minerals in land located or sold under the Free Grants act, which are reserved and are the property of the crown. Two or three witnesses are of opinion that as a matter of arrangement a person discovering ore or mineral on land already patented might be allowed to work it upon payment of a royalty to the owner, and that such arrangement might have the sanction or authority of law. Another witness states that this is the practice in Germany, where one may go on any person's property by obtaining permission from the government, and in case he cannot agree with the proprietor on the amount to be paid the government steps in and the matter is settled by arbitration. And the witness adds that in his own experience of fifteen years in that country he never had any trouble with the owners; they were always glad to make an arrangement. But in the sale of lands in Germany the minerals are reserved, and the government claims a royalty of two per cent. in kind in addition to the interest paid to the owner of the property. Only one witness ventures to say that it is desirable in this country to return to the royalty system, and he thinks it would not be unjust even to reclaim the abandoned royalties, as when selling the land the government got nothing for the minerals.

Speculation in mining lands.

Speculation in mining lands is regarded by nearly all the witnesses as baneful, and especially in cases where large blocks are held. The loudest complaints are made in the lake Superior region, where a great deal of territory is locked up. Nearly the whole country is bought up on speculation, one witness states, and people are asking $1,000 to $100,000 for locations upon which a dollar's worth of improvement has not been done. Many people come in, a witness of Denison township says, and finding the land all taken up they go away and do not come back again at all. The holding of land for speculative ends stops prospecting, keeps out *bona fide* miners and retards the development of the country; such is said to be the general effect. Two witnesses only express a different opinion, one denying that the practice has hindered prospectors or kept back development, and the other stating that all the prospector can do is to find the mineral: capital has to take the risk of developing it. The latter stands alone in opposition to the proposed remedial measures; restriction of areas and compulsory work, he says, would lead to evasion. All other witnesses are agreed that the land should be held subject to certain conditions of mining development, and several suggest that, failing the conditions, the land should revert to the crown. The quantity of land would not so much matter, Dr. Selwyn observes, if the conditions for working it bore some relation to the extent of the area; and this is the prevailing opinion. One important feature of the evidence deserves to be emphasised, viz.: that rich men are not the only owners of land held for speculation. Many prospectors are also holding for the same object, having neither means nor intention to work the properties they have acquired. Rich and poor are in many cases alike indifferent to the economic fact that, in the words of one of the witnesses, "the development of the property is what gives it value."

The right to explore patented lands is suggested by several witnesses as a remedy of the evil of locking up large blocks for speculation. It is thought that the owners of such lands would not object to an arrangement whereby their property might be explored and a royalty paid to them on minerals taken out. Some plan of this kind, it is claimed, would be in the interest of the country, and even if owners of the land were compelled by law to enter into an agreement with explorers, they could not reasonably complain of injustice. Prospectors should have the right to go on all lands held for speculation, one witness says, and should be guaranteed an interest in whatever minerals may be found or allowed to work them on a royalty, first giving the owners of the land a certain time to explore and develop it before such a provision of the law was allowed to come into operation against them. Another advises that an act should be passed to enable an explorer to locate a claim wherever minerals occur if the owner will not work them, subject to a royalty of say 5 per cent. and 2½ per cent to the government—companies holding large areas to be compelled to take a fixed royalty or to work the mines themselves. Mr. Gordon, who represents a large land company in Haliburton, has no doubt that his company would willingly give prospectors a half interest in anything they found, but does not consider that the government should give the prospector a right to go on private land without compensation. Mr. Cattanach, who has had a large experience with mining enterprises, thinks it would be advisable, after lands have been patented five years without development, that any person should be allowed to go on them and prospect. This might be done by giving the discoverer the right within a limited time of working the find, subject to payment to the owner of 25 per cent. of the profits if the owner did not exercise the option of working it himself within the same time and giving to the discoverer the same percentage of profits; either one being at liberty to take up the work on his own account, under circumstances which would forfeit a claim under the general mining laws. But he thinks that a law authorising an arrangement of this kind should not apply to lands already taken up, as it would be an interference with vested rights and tend to frighten foreigners who supply nearly all the money that is spent in mining. It is not, however, within the knowledge of any of the witnesses that a country which once abandoned all right and claim to minerals on lands sold to private individuals has sought to reclaim the minerals on such lands or to legislate for their development, either with or without provision being made for compensation.*

Exploration of patented lands.

Mining lands like other public lands purchased from the crown in the unorganised districts are subject to a yearly tax of one cent per acre. This is supposed to operate against the practice of holding mineral lands for a speculative object, and it is stated that many locations are sold every year for arrears of taxes. One witness suggests that the rate should be increased with a view to prevent purchase by speculators, while others are of opinion either that it is sufficiently high now or that it is an utter failure as a scheme for enforcing development of the property. One result secured by the system

Taxation of mining lands.

*The South Australia law relating to mining on private property appears to contain such a provision—implied, if not definitely expressed.

of taxation is a change in the ownership of the property, in many cases, but that may or may not lead to any practical benefit in so far as concerns mining operations.

Destruction of timber by fire, through the wilful or careless conduct of explorers.

The destruction of timber by forest fires is complained of by several witnesses as inimical to the mining industry, and one witness states that in some instances prospectors have no objection to the spread of fire as it uncovers the rock, thereby facilitating the discovery of veins, and that they have been known to start fires for that object. The same witness admits, however, that it is difficult to ascertain if a fire has been set out purposely, but thinks it is fair to presume that where a prospector leaves his camp-fire burning he is guilty of criminal carelessness. In the lumbering regions greater care is exercised for the prevention of fires than in regions where timber of no merchantable value exists, and with the conjoint efforts of the government and limit holders it is admitted that every reasonable precaution is taken to preserve the forests from destruction by fire.

The mining division system.

The mining division system, as provided for in the mining act, does not seem to be held in favor by prospectors, miners or owners of mineral land. Two divisions were established in the province under the acts of 1864 and 1869, one in the Bay of Quinté and the other in the lake Superior district, but after an experience of the system extending over several years the orders in council creating the divisions were cancelled. The provisions of the act still remain, however, and may be put into operation whenever or wherever it is deemed expedient by the government.

Underground boundaries of mining properties.

Complaint is made by one witness of the injustice which may be done to mine-owners in not allowing them to work a vein where it dips outside vertical lines along the boundaries of their own property. He thinks the miner should have the right to follow his vein wherever it goes, and instances the wrong done to a Scotch company which spent $500,000 on a property and had to abandon it because the vein dipped into an adjoining property. Several Ontario mines, he states, are in a similar condition on this account. It does not appear, however, that the mining act makes any provision for such a case on mining locations. It is only in the case of mining claims taken up in an established mining division that the miner's right in his vein is dealt with. "The ground included in every claim," section 20 of the act provides, "shall be deemed to be bounded under the surface by lines vertical to the horizon; except that every mining claim shall include and shall authorise the licensee to work every dip, spur and angle of the vein or lode laterally to the depth to which the same can be worked, with all the earth and minerals therein." The right to follow the vein wherever it may lead seems to be implied here; but, as previously stated, no provision is made as to property right in a similarly occurring vein on a mining location.

Health and safety of workers.

No complaint has been made by miners or others of the absence of provisions in the mining act for the health and safety of mining employes; doubtless for the reason that the number of deep working mines in the country are few, and that so far, fortunately, accidents have been of rare occurrence.

MINING LAWS IN ONTARIO AND ELSEWHERE

II. A full account of mining laws in even the principal countries of the world would take up a space far beyond the limits assigned to this part of the report. Wherever mining operations are carried on the laws have been changed from time to time as experience has seemed to show the necessity for amendment, and the record of legislation in the United States and Canada alone would fill several volumes. Our experience in Ontario extends now over a period of forty-four years, and if some wisdom has been gained it is desirable to trace the steps of progress, and especially to learn what plans and provisions have succeeded or failed, in the hope that we may be intelligently directed in the way of further improvement. We have also, doubtless, something to learn from the experiences of other countries, but as regards these it will suffice, perhaps, to summarise the existing laws. Value of experience.

ONTARIO.

It does not appear that any laws or regulations concerning mines of mining were adopted in this province previous to 1845, the first season or exploration and discovery in the lake Superior region, and for the first year each case requiring executive action was dealt with as it arose by order in council. Several points settled in this way were embodied in an order approved by the governor-general in council on the 12th of December, setting forth as follows: First regulations in Ontario

1. That the fact of having made prior explorations will form the ground of application for license to occupy and open the mines. Explorer's right.

2. That each party will be called upon to furnish particulars of such exploration, the several steps taken to obtain information, the result in detail of their discoveries, the character of the various veins or beds of ore, their probable extent and richness, and such other particulars as a rough geological enquiry by a scientific man might be expected to furnish. Explorer to report.

3. That, to guard against a perversion of the intentions of the government in granting licenses, the different applicants should furnish the names of all the parties forming each association, that no licenses will be granted to other than British subjects, and that no transfer or assignment of interest will take place without the sanction of the government unless the parties are British subjects. Licenses reserved to citizens.

4. That no license of occupation be issued until the provincial geologist or other scientific agent of the government shall have had an opportunity of marking the boundaries of the several limits, and of examining and remarking upon the statements furnished by the several exploring parties. Scientific survey.

On the 7th April, 1846, the council fixed the extent of a mining tract or location at one mile in front by five miles in depth; and on the 18th of the same month, upon the petition of parties interested in mining explorations, the limit was extended to two miles in front by five in depth. Size of first locations.

On the 9th of May a set of revised regulations was approved, providing as follows: Regulations of 1846.

1. Each license to explore to have one location. One location.

2. A location to consist of five miles in length by two in breadth, the length thereof to be with the course of the mineral vein. Size of location.

3. The geologist to determine the direction in the case of different courses on adjoining locations. Ccurse of vein.

4. A land surveyor to fix the limits of each location, and forward a description to the government. Survey.

5. Priority of discovery by exploration to be the foundation of priority of right to any location claimed. Priority of right.

6. Reports pointing out and selecting a location to be classed according to receipt, and to be the best evidence of discovery; possession by the erection and Evidence of discovery.

occupation of a hut to be the next best, and it shall not be competent for a party to occupy more than one hut as a mark of location at the same time; priority of application to be the next best.

Tenure of locations.

As to the tenure of locations, the government was for some time undecided between a policy of sale in fee simple and one of conveyance by lease for a term of twenty-one years. Finally an order in council approved 7th October, 1846, settled the terms of possession as follows:

Option of purchase.

The several license holders will be permitted to work the mines under the authority of the licenses which they now hold, with the option, either now or at any time within the period of two years, to purchase the location of ten square miles at the rate of 4s. per acre, payable one-fifth part in hand and the balance in five yearly payments with interest.

Certificate of location.

This regulation was followed by another on the 2nd of November, which provided that a license-holder should be entitled to a certificate of location from the commissioner of crown lands upon payment of £150, to cover the cost of survey and other contingent expenses—this sum to be placed at the credit of the locatee as a part of the first instalment when the sale was confirmed, and to be forfeited to the government in case of failure to make good the payment of that instalment within the period of two years.

Regulations of 1853.

No further change in the regulations was made until 1853. A report to council made by the commissioner of crown lands in that year represented that the existing system of allotting mining tracts had not realised the anticipations formed of it, nor had it enabled individuals desirous of engaging in mining pursuits to effect their objects without compelling them to purchase locations of so extensive an area as to occasion a needlessly large expenditure of capital on acquiring a right to explore and mine where the indications were favorable. Therefore he advised such change in the regulations as would combine, with a right to explore during a limited period on favorable terms, the privilege of purchasing tracts of very moderate extent, providing the exploration proved satisfactory. In accordance with the commissioner's recommendation, regulations were adopted to the following effect:

License to explore.

1. That upon payment into the hands of the commissioner of crown lands of the sum of £25, that officer be permitted to issue a license to any individual authorising him to explore upon any unconceded lands within the limits of any such county or section of country as he may desire to be inserted, situated within the boundaries of Upper Canada, for copper, lead, iron, tin, marble, gypsum, earth or minerals.

Area of tract.

2. Such license to remain in force for a period of two years, and to authorise the individual in whose favor it was issued to take possession of a tract not exceeding 400 acres and not already occupied by any other person—such tract to be in the proportion of 40 chains front by 100 chains in depth.

License-holder to report discovery.

3. The license-holder to report his discovery and selection accurately by letter and map within six months from the issue of his license, accompanied by an affidavit made by himself and some other credible persons, proving that no counter occupation or workings exist.

Right of purchase.

4. And at the expiration of such term of two years, during which the license shall have force, he shall complete a purchase, paying the consideration money in one sum, at the rate of 7s. 6d. per acre, or, failing to do so, he shall be regarded as having abandoned such right to purchase.

Regulations of 1861.

The next important change in the regulations was made on 15th March, 1861, when the following were substituted for the regulations of 1853:

Terms of granting tracts.

1. That for mining purposes tracts comprising not more than 400 acres each be granted to parties applying for the same, at the rate of $1 per acre, to be paid

in full on the sale, the applicant furnishing a plan and description of the locality to the department of crown lands, and on condition that such mineral location be worked within one year from the date of grant.

2. That no patent therefor issue until two years from the date of the purchase, and then only upon proof that the purchaser or his assignee has continued to work said location bona fide for at least one year previously. Condition of patent.

3. That the fee of $100 (£25) for permission to explore, now charged, be abolished. Explorer's fee abolished.

4. That locations be sold to the first applicant agreeing to the terms above specified. Prior claim.

5. That these regulations shall not apply to mines of gold and silver.

On the 21st of April, 1862, another radical change was made in the regulations; simplifying them as to the conditions of purchase, but providing for a royalty on the ores. The new order set forth : Regulations of 1862.

That in all future sales of mineral lands a royalty of $2\frac{1}{2}$ per cent. on all ores extracted be charged, payable in cash, on the value of the ore prepared for market at the mine, and that letters patent be issued for such lands on the payment of the purchase money without any additional conditions ; also that lots in surveyed townships, presenting indications of minerals, be sold at the same price per acre as the lands adjacent, subject to the above-mentioned royalty. Royalty.

Those conditions of sale and location of mineral lands were again changed on 3rd March, 1864, by the substitution of the following regulations : Regulations of 1864.

1. That the tracts shall comprise not more than 400 acres.

2. That the dimensions of the tracts in unsurveyed territory be 40 chains in front by 100 chains in depth, and bounded by lines running due north and south, and east and west, or as near to these dimensions as the configuration of the locality will admit. Dimensions of tracts.

3. The applicant for a tract in unsurveyed territory must furnish a plan and description thereof by a provincial land surveyor. Plan to be furnished.

4. The price shall be $1 an acre, payable on the sale. Price.

5. That a tax or duty of $1 per ton be charged on all ores extracted from the tract, payable on removal from the mine. This condition applies to all mining lands sold since the 1st day of April, 1862, and is in lieu of the royalty of $2\frac{1}{2}$ per cent. chargeable on the ores from these lands.* Tax substituted for royalty.

6. That in surveyed townships lots presenting indications of minerals be sold on the above conditions, but at not less than $1 per acre in any township, and at the same price as the other lands in the township when it is more than $1 per acre. Price in surveyed townships.

7. That not more than one tract of 400 acres be sold to one person. Limit of purchase.

The first mining act of the united provinces of Upper and Lower Canada, known as the Gold Mining act, was passed in the session of 1864, and received the royal assent on the 30th of June. It was an act of 40 sections, drawn up with great nicety and particularity for the working of quartz and alluvial mines and for the protection of miners' rights in their locations. It provided for the institution of mining divisions, for the appointment of inspectors of divisions with large powers, for the staking of claims, for licenses to mine, for licenses to mill, for sworn returns of gold taken out, for preservation of the peace, and generally all the legislative trappings of a placer-diggings gold land. Following is a summary of its chief provisions : The Gold Mining act of 1864.

1. The divisions were created by order in council, and an inspector for each division had the administration of the act in his hands, within the limits of his tract. This officer was clothed with power to settle summarily all disputes as to extent or boundary of claims, use of water, damage by licensees to others, forfeiture Mining division and inspectors.

*By an order of 10th June following, it was provided that this duty should not come into effect until 1st April, 1865.

of licenses, and all difficulties and matters arising under the act or offences against any of its provisions, and generally his decisions were to be final.

Gold mining license.

2. The act made it unlawful for any person in a mining division to mine for gold either for himself or any other person, except under a crown lands or a private lands license; but it was generously provided that no license fee should be exacted for exploring for gold until the precious metal was discovered. The crown lands license was issued at a fee of $2 per month, and authorised the holder of it to stake out and mine one claim on any unsold crown lands within the mining division. The private lands license was given for a fee of $1 per month, and authorised the holder to mine on private land with the consent of the owner to the limit or extent agreed upon between the parties. It was allowable, however, for any proprietor of a lot to take out a license for each miner working upon his land, in the name of such miner. To entitle himself to renewal of license the miner was required to make a full and true statement upon oath of the labor performed and the gold obtained by him during the term of his expired license.

Dimensions of claims.

3. The dimensions of an alluvial claim were, if on a river or large creek, 20 feet front by 50 feet to the rear, from the water's edge; if on a small creek, 40 feet front by 50 feet to the rear, from the centre of the stream; if in a gully, 60 feet along the gully, from hill to hill; if on a surface or hillside digging, 60 feet square; and if in the bed of a river, such size and position as the inspector might determine. For a quartz claim a person might take 100 feet along a lead by 100 feet on each side, from the centre of the lead; but companies of two or more persons might stake out and work additional feet along the lead within the proportion of 25 feet for every miner, not to exceed 500 feet, and work the claim jointly.

Boundaries of claims.

4. Claims were to be laid out as far as possible uniformly in rectangular shapes, measurements to be on the level, and all claims to be bounded under the surface by lines vertical to the horizon.

Conditions of license.

5. On crown lands licensees had the right of continued occupation of a claim subject to the condition of continuous working and without intermission for a longer period than one week, and subject also to compliance with the requirements of the act and the regular renewal of licenses; and no person was allowed to occupy at the same time more than one claim on crown lands.

Discoverer's right.

6. The discoverer of a new mine was entitled to a license free of fees for twelve months for one claim of the largest area; but no one could be regarded as a discoverer unless the place was at least three miles from the nearest known mine on the same quartz lead, or at least one mile at right angle from the course of the lead, and if in alluvial workings at least two miles from any previously discovered mine.

Mill license.

7. No mill or other machinery for crushing or reducing ore in a mining division, other than hand mills, could be used without license, issued at a fee of $5 per month; and a full and particular statement under oath was required to be made monthly to the inspector by the mill-owner, giving the name of the owner of each parcel of quartz crushed, its weight and the yield in weight of gold from each parcel.

Royalty abandoned in part.

This Act did not make any change in the March regulations of the same year. But on the 12th of April, 1865, it was ordered that the clause requiring payment of one dollar per ton on all ores extracted from lots sold as mineral lands should no longer be inserted in the grants of such lands; and also that in letters patent for lands on the shores of lakes Huron and Superior the clause reserving all mines of gold and silver might be omitted at the discretion of the commissioner of crown lands. So the regulations stood until 13th July, 1866, when the following changes were made in respect of all minerals and ores excepting gold and silver:

Regulations of 1866.

Mining tracts in unsurveyed territory.

1. Each regular mining tract in unsurveyed territory to consist of blocks of 200 to 400 acres; the tracts to be surveyed by a provincial land surveyor and connected with some known point in previous surveys at the cost of the applicant; and the applicant to furnish the surveyor's plan, field notes and descriptions, and pay the price of one dollar per acre to the department of crown lands at the time of making application.

In surveyed townships.

2. In surveyed townships lots that present indications of minerals to be sold on the above conditions, but at not less than $1 per acre in any township, and at the same price as other lands in the township where it is more than $1 an acre.

3. Mining lands in surveyed townships to be sold by the local agents for cash, but all lands in unsurveyed territory to be sold by the department. By whom to be sold.

In respect of gold and silver the regulations provided that in gold mining divisions the department should discriminate as far as practicable between purchasers for actual settlement and those for mining and speculative purposes; and that "in all letters patent for lands the clause reserving all mines of gold and silver be omitted." Gold and silver royalties.

On the last day of the session of 1868, being the first session of the legislature of Ontario under Confederation, a bill was introduced and put through its several stages under the title of an act respecting Gold and Silver Mines. It was based on the act of 1864, but, in consequence of recent discoveries of silver on the north shore of lake Superior, its provisions were made to extend to silver as well as gold. The commissioner of crown lands in introducing his measure stated that the act of 1864 had imposed a fee under which parties were allowed to work gold mines instead of a royalty, but as this plan was proved to be practically a failure he proposed to substitute a miner's license and royalty instead of a fee. Among the new or amended provisions of the act were the following: The Gold and Silver mining act of 1868. The miner's license and royalty system.

1. That on payment to him of a fee of $5 an inspector of a mining division might grant to the party applying therefor a miner's license for one year, with the right of renewal on payment of the same fee, and authorising the holder to explore and mine for gold and silver one staked claim on any unsold or unoccupied crown land in the division. Miner's license.

2. That for alluvial mines a claim on any river, creek, gully or sidehill should be 100 feet square; and for quartz mines, 150 feet along a lead by 100 feet on each side measured from the centre, with 100 additional feet for each miner of a company of two or more to work the claim jointly, not to exceed 1,000 feet altogether. Area of claims.

3. That the proprietors of all private lands in a division should have the right to mine for gold and silver on their own lands, subject to a royalty of two to ten per cent. as fixed from time to time by order in council, and that payment of the same royalty should also be required of all miners working claims on crown lands; each licensed mill-owner to keep back and pay the royalty on each lot or parcel of quartz as crushed, as shown by his books, and to be allowed five per cent. on the amount paid over by him to the treasurer of the province for his remuneration. Royalty.

The measure did not carry, however, without severe criticism. It was declared that a retrogade line of policy was being adopted, that several of the provisions imposed substantial fetters on transactions, that the effect of the royalty would be to drive miners away, and that such a policy was most unwise in view of the hopelessness of developing our mines except with foreign capital. To these objections the government replied by stating that they had not been able to procure sufficient information upon which to frame a perfect or final measure; that this one was in the nature of an experiment until the next session of the legislature, when a more matured scheme would be presented; but that they were prepared to stand or fall on the royalties. Criticism of the measure.

During the recess several petitions were presented to the government for and against the provisions of the new act, and in the following session a bill was introduced and carried which, with one amendment, has remained the mining act of the province to the present time. Following are its chief provisions: Mining act of 1869.

1. All royalties reserved by any patent, and all taxes or duties made payable upon ores or minerals taken from lands granted by such patents are repealed and abandoned, and lands, ores and minerals are henceforth free from every royalty, All royalties repealed and abandoned.

tax and duty; and all reservations of gold and silver mines in any patent already issued are made void, no reservation or exception of any minerals to be hereafter inserted in any patent granting lands in the province sold as mining lands.

Freedom to explore.

2. Any person may explore for minerals on any crown lands not marked or staked out and occupied.

Mining locations and mining claims.

3. Crown lands supposed to contain minerals may be sold as mining lands, and to be known as 'mining locations' when situate in unsurveyed territory or in townships surveyed in sections; or may when situate within a mining division be occupied and worked as 'mining claims,' under miners' licenses.

Form and extent of mining locations.

4. Mining locations in the unsurveyed territory north or north-west of Mattawan river, lake Nipissing and French river, including the territory bordering on lakes Huron and Superior and the river St. Mary, must be rectangular in shape and of one of the following dimensions, viz.: 80 by 40 claims containing 320 acres, or 40 chains square containing 160 acres, or 40 by 20 chains containing 80 acres; and in townships of the same territory surveyed into sections each location must consist of a half, a quarter or an eighth section; but in unsurveyed lands outside of said territory the extent of locations is as may be defined by order in council.

Surveys of mining locations.

5. Mining locations in unsurveyed territory must be surveyed by a provincial land surveyor and connected with some known point at the cost of the applicants, who are required to furnish the department the surveyor's plan, field notes and description, with their application.

Price of mining lands.

6. The price of all crown lands sold as mining locations in the northern territory was $1 per acre until 1886, when by amendment of the act it was raised to $2 per acre.

Use of timber on mining lands.

7. The patents for all crown lands sold as mining lands reserve all pine trees on such lands, and any person holding a license to cut timber on such lands may cut and remove the pine; but the patentees may cut and use as many trees as may be necessary for building, fencing, fuelling and mining purposes, and all trees required to be removed in clearing the land for cultivation.

Mining divisions.

The remaining provisions of the act refer to mining divisions, and are based on those of the acts of 1864 and 1868, but with the sections which provide for the leasing of gold and silver mills and the payment of royalties omitted. The clauses relating to alluvial claims are also omitted, and the dimensions of a claim are extended to 200 feet along the vein by 100 feet on each side of it, measured from the centre, but with the same limitations as in the act of 1868 in the case of two or more persons working a claim jointly. The rules as to laying out claims continue as in the act of 1868, but the section defining the bounds of a claim under the surface are amended by an additional clause. The act of 1868 provided that "the ground included in every claim shall be deemed to be bounded under the surface by lines vertical to the horizon;" to which the act of 1869 adds the exception "that every mining claim shall include and shall authorise the licensee to work every dip, spur and angle of the vein or lode laterally to the depth to which the same can be worked, with all the earth and minerals therein." The effect of this qualifying clause, however, is not very clear.

Scheme of the act.

The general scheme of this measure, as explained by the commissioner of crown lands on the second reading, was to encourage practical miners by opening to them a promising mineral district under the leasing or licensing system; and also to encourage capitalists by enabling them to get possession of large blocks by purchase. As originally drawn, the bill fixed the area of a mining location at 320 acres, but the views of members were met by fixing the minimum at 80 acres for the accommodation of explorers and practical miners. Several leading members urged that miners should be allowed to take up 40 acres. No provision was made for the working of locations

Size of locations.

for the reason, as stated by the commissioner, that experience had shown them to be ineffectual. Neither was any limit placed on the number of locations one person might purchase, because a former regulation limiting an individual purchase to 400 acres had failed of its object. It had been evaded by persons taking up other lots in the name of their friends. Frauds of this kind, it was said, could not be prevented by statutory enactment, and it was idle to cumber the statute book with provisions which were sure to be evaded. It was only in the case of mining claims—small blocks of 200 feet square—that provision was made to limit individual holdings and to impose working conditions. Only the discoverer of a mine is entitled to two claims, and the claim of any licensee is forfeited upon its remaining unworked a specified time. No regulations have been made under the act.

Old conditions abandoned.

QUEBEC.

The mining act of the province of Quebec consists of 161 'articles' or sections, and is similar in its leading provisions to the French mining act of 1810. Following is a summary of the act:

Quebec mining act.

1. In letters patent for lands granted for agricultural purposes the reserve of mining rights to the crown is assumed and these rights are a property separate from the soil, constituting a public property independent from that of the soil which is above it, unless the proprietor of the soil has acquired it from the crown as a mining location or otherwise.

Mining rights reserved to the crown.

2. Any person who obtained a lot of public land for agricultural purposes previous to July 24, 1880, who discovers a mine upon it, may purchase the mining rights reserved by the government by paying in cash to the commissioner over and above the price already paid enough to make up $2 per acre if for gold or silver, and $1 per acre if for copper, iron, lead or other baser metal; and in the case of land sold for agriculutral purposes without reservation by the government, the owner who discovers gold or silver upon it may work the same without license by paying to the commissioner, over and above the price already paid, enough to make up a total of $2 per acre. If on lands granted for agricultural purposes since March 9, 1878, phosphate of lime has been discovered, the owner if he wish to work the mine must pay to the commissioner enough to make up a sum of $2 per acre; and in the case of discovery of any of the base metals he may acquire the same right upon payment of enough to make up $1 per acre. If on lands purchased for the purpose of mining for base metals the owner discovers a mine of gold or silver, he may work such mine upon payment to the commissioner over and above the price already paid enough to make up a sum of $2 per acre; and the same rule applies in case of a discovery of phosphate of lime upon lots sold since March 9, 1878. But the lieutenant-governor in council has power to increase the price per acre of lands found to contain minerals, beyond the foregoing specified prices.

Private owner may purchase the reserved rights.

Phosphate of lime and the base metals.

3. The lieutenant-governor in council may claim at any time the royalty due to the crown upon any land sold or otherwise alienated; and, unless the rate is otherwise established by title from the crown, it shall be $2\frac{1}{2}$ per cent. on the gross amount of gold or silver and fifty cents on each ton of phosphate of lime in its raw state.

Royalties.

4. The lieutenant-governor may by order in council erect any portion of the province which he may think proper into a mining division, and enlarge, diminish or abolish it as he sees fit.

Mining divisions.

5. All lands supposed to contain minerals or ores in the province may be acquired from the commissioner by sale and patent as a mining location, or be occupied and worked as a mining claim under a license. Mining rights under the soil belonging to the crown may be acquired from the commissioner by sale or lease, or by license or permit of occupation, by the proprietor of the soil, who has a preferential right to purchase of the mining rights; and in the event of the proprietor of the soil refusing or neglecting to work the mines, any miner may acquire the rights after putting the proprietor in default and paying upon mutual agreement or the award of arbitrators all the damages and losses which he may cause in mining under the soil. The price of the sale, the amount of the lease and the fee

Mining locations and mining claims.

for the leasing or royalty and all other conditions are fixed by the lieutenant-governor in council, as well as the form or extent of the underground mining locations. Under a written permission to that effect from the Commissioner any person may prospect for minerals or ores upon public lands not already occupied as mining claims or otherwise; but the person obtaining such a permission is required to accompany his application with a fee of $2, to give an exact description of the lot required, and to furnish sufficient security for losses or damages which he may cause to the owner of the soil in making searches; and he is required to make a report of his operations within one month after the expiration of his permission.

License to prospect for minerals.

6. No sales of mining locations containing an area of more than 400 acres can be made to the same person, excepting that upon sufficient proof of his capital and resources the lieutenant-governor in council may grant a location not to exceed 800 acres. Mining locations are divided into three classes, those of the first containing 400 acres 52 chains in width, those of the second 200 acres 26 chains in width, and those of the third 100 acres 13 chains in width. In unsurveyed territory the locations are required to be surveyed by a provincial land surveyor acting under the instructions of the department of crown lands, and must be connected with some known point in previous surveys, and such surveys are required to be made at the cost of the applicants and the plan and field-notes furnished to the department along with the application to purchase.

Extent of mining locations.

Surveys.

7. Purchasers are required to pay cash for locations at the rate of $2 per acre if for the working of gold, silver or phosphate mines, and $1 per acre if for the mining of baser metals; but no lands are so sold unless there be real indications of the presence of minerals, proof of which must be shown by specimens found upon or in the lands and affidavits of competent and credible persons establishing that the specimens came therefrom. All trees of pine or spruce twelve inches and upwards in diameter on lands sold as mining locations are reserved to the crown, but the owners of locations have the right to take for their own use such trees as they may require for their operations. The patent for a location sold as either gold or silver mining land is granted only after proof has been given to the satisfaction of the commissioner that mining has been commenced in good faith, under license, and a sum of not less than $200 has been expended by the purchaser of the location; and if such mining works have not been commenced and $200 expended after two consecutive years, the land may be confiscated by the commissioner and again sold to any other person. In a mining division every miner is required to obtain from the inspector a license, at a fee of $2 for every three months.

Proof of existence of minerals must be shown.

Pine and spruce reserved.

Conditious of patent.

8. All officers of mining divisions are under the general control of the commissioner, including inspectors and policemen, and every inspector or other officer who receives public moneys is accountable to the commissioner therefor.

Officers of divisions.

9. Licenses to work mines are granted by the inspector of each mining division, and the inspector is bound to keep a register of licensees and a description of mining claims taken, which is open to the inspection of any one upon payment of a fee of twenty cents. In the case of mines beyond the limits of mining divisions the commissioner may grant licenses at his discretion.

Licenses to work mines.

10. The inspector or other officer of a mining division may at any time enter upon private or public lands that are being mined and examine the works upon them, requiring from the proprietors or employés all the facilities and assistance necessary for the purpose; but no inspector can either directly or indirectly take any share in the working of mines in the division for which he has been appointed without rendering himself liable to dismissal from office and to a fine not exceeding $400.

Powers of mining division officers.

11. Every person, firm or company is prohibited from mining for gold or silver in a mining division, either upon private or public lands, without having previously obtained a license for himself (firm or company) and for and in the name of every person employed and working on the property in any way whatever; but in the case of mining locations acquired by purchase from the crown the persons working them are required to take out only one license for every mine, at $2 for every three months; and any person who contravenes these provisions is liable to a penalty.

Licenses to work claims and locations.

12. Licenses to mine for gold and silver are of three descriptions, viz.: (1) Private lands' gold or silver license, granted upon payment of a fee of $1 per month for each miner; (2) Public lands' gold or silver license, granted upon payment of a fee of $2 per month for each miner; and (3) Licenses for the working of mining locations, upon payment of a fee of $2 for every three months. But the lieutenant-governor in council may require the payment of the royalty in lieu of fees.

Three descriptions of licenses.

13. In the case of mines on private lands the owner may take out a license and mine on his own land as a preferred right, providing that he has not divested himself of his mining rights in favor of a third party; otherwise any person holding a private lands' gold or silver license may apply to the owner of the land by petition, representing that he is ready to pay damages arising from mining operations to be assessed by mutual agreement; and should the owner decline to avail himself of the right to mine the property, or refuse to come to a mutual understanding with the petitioner, the matter can be decided by arbitration. Mines on private lands.

14. The holder of a license to mine for gold or silver upon public lands has a right to take out one claim in a mining division, or upon unoccupied public lands, by staking and working the claim. Public lands' license.

15. The size of a claim for alluvial mines on a river is 40 feet front by 80 feet deep, from the water's edge; on a small stream, 60 feet front by 100 feet deep, from the centre of the stream; in a gully, 100 feet along the gully and from hill to hill; on a plain surface or hill-side, 100 feet square; and for working the bed of a river, such size and position as the inspector may determine. For quartz mines the size of a claim for one person is 150 feet along a lead by 25 feet on each side, measuring from the centre; and for companies of two or more persons, 50 feet additional in length for every additional miner, not to exceed 700 feet, and they may work the claim jointly. Claims are laid out as far as possible in quadrilateral and rectangular shapes, measurements are horizontal, and the land included in each claim is deemed to be bounded under the surface by lines perpendicular to the horizon. Sizes of alluvial and quartz claims. Underground boundaries.

16. Every licensee, after staking out a claim upon private or public lands or acquiring a mining location, is bound to give a written notice to the mining inspector within thirty days, indicating where the claim is situated, giving a complete description of it, and showing how and when it was staked out; and no person can occupy at the same time more than one claim on crown lands except in the cases of claims rendered temporarily unworkable. The discoverer of a new mine is entitled to a free license for twelve months for one claim of the largest area; but no person is considered a discoverer of a new mine unless the place of discovery if upon a known lead is at least three miles from the nearest known mine on the same lead, or one mile at right angles from the course of such lead. Every person holding a license is bound upon renewing it to make to the inspector of the division a full and true statement under oath of the work performed and the gold or silver obtained by him during the term of the expiring license. Notice of staked claim to be given to the inspector. Right of discovery. License holder must report operations.

17. The sale or exchange of intoxicating liquor within a radius of seven miles of any mine in operation is prohibited unless a license therefor has been obtained from the inspector of the division; and the inspector alone may refuse or grant such licenses, or cancel them, within a radius of seven miles of a mine. Liquor licenses in mining divisions.

Various other provisions of the act refer to mill-owners, the mining and crushing of ores, penalties for contraventions of the act, regulations respecting mining, powers and offices of mining inspectors, etc. The commissioner of crown lands is authorised to procure geological explorations or other searches of the country in order to ascertain what lands contain ores or valuable deposits, and to make surveys of the limits of mining locations. He may also reserve from sale for colonisation purposes lands in which the existence of mines which may be worked has been established, and may offer them for sale from time to time by public auction at an upset price of $2 per acre, and the entire price is payable in cash. Other provisions. Geological explorations and surveys of mining divisions. Sales of mining lands by public auction.

NOVA SCOTIA.

The law of Nova Scotia relating to mines and minerals was consolidated in 1884, but has since been amended in some particulars; it consists of 138 sections. The regulations of mines are also statutory, and follow very closely the British regulations of 1872. The administration of the law and regulations is entrusted to a commissioner of mines, whose office hours extend from 10 in the forenoon to 4 in the afternoon (but closing at 1 p.m. Saturday), and all applications made at other times than within those hours are void. The Laws and regulations.

commissioner is also assisted by a deputy and an inspector,—the latter being required to possess the qualifications of a competent, scientific practical mining engineer, whose duty is to visit and inspect the various mines belonging to or under lease from the crown and report on their working, means provided for their safety, payment of rents and royalties, etc.

Provisions relating to gold and silver.

As regards gold and gold and silver mines, the act provides :

Gold districts.

1. Upon the discovery of such metals or ores in any locality, the governor in council may declare the locality to be a gold district, fixing its limits; and the commissioner is required to keep in his office books of record for all districts or places in which applications for leases and prospecting licenses are entered, together with plans of districts on which all areas applied for are designated by numbers.

Size of mines.

2. Quartz mines are laid off in rectangular areas of 150 feet lengthwise of the general course of the strata by 250 feet across, each area bounded by lines vertical with the horizon ; and alluvial mines which may be under lease are required to be laid out on the same plan when surrendered to the crown, and subject to the same rents and royalties as quartz mines.

Leases of areas.

3. Applications for leases of areas are made to the deputy commissioners of the districts, or to the commissioner where there are no deputies, each of which must define in writing the area or areas applied for and be accompanied by a payment of $2 for each area ; and where a lease is granted on private land the lessee is required before making entry to obtain permission from the owner, either by terms mutually agreed upon or by arbitration between the parties.

Term of a lease.

4. All leases are for a term of twenty-one years, but the owner may surrender at any time by notice ; or they may be forfeited on failure to comply with the stipulations.

Conditions.

5. Each lessee is required to put on every area comprised in the premises covered by his lease the equivalent of forty days' labor each year ; or three-fourths of the days' labor per area in the first year if the number of areas held be ten or more but less than twenty in the same district ; or one-half if holding twenty or more but less than thirty ; or one-fourth if holding thirty or more. The total of mining areas held in a district by one person cannot exceed one hundred, and the law is held to be complied with in the case of a person who expends on one or more areas an amount of labor equal to what is required to be performed on the whole ; and in the event of a lessee failing to expend the whole of the labor so required he is permitted to retain areas proportioned to the labor bestowed, but the areas so retained must be as far as possible in a compact block. When the stated labor has been employed on the premises for a period of ten years the lease is not liable to forfeiture for non-compliance with this requirement during the remainder of the term.

Areas outside of proclaimed districts.

6. Any person occupying and staking off areas (not exceeding 100) outside of a proclaimed gold district is entitled to a license or lease in preference to any other applicant, and is allowed one week thereafter for making his application, and twenty-four hours additional time for every fifteen miles distance of the property from the office of the commissioner.

Prospecting licenses.

7. The commissioner may issue prospecting licenses to search for gold and silver on territory not exceeding one hundred areas, to remain in force for a period not exceeding six months, at a fee of fifty cents per area up to ten, and of twenty-five cents for every area in addition ; but before the license is issued the applicant must enter into a bond with two sureties to recompense the owner of the soil in the event of entry being made on private lands for damages done, to make returns at the expiration of the license and to pay the royalties. Such license may be renewed for a second period of six months upon payment of half the fees required at the previous application, and within the period of his license the party may select areas for lease ; but the licensee or lessee cannot enter upon any buildings, garden, orchard or growing crops on the premises except with the consent of the occupier or by license from the governor in council.

Royalty.

8. On all leases of gold and gold and silver mines and prospecting licenses to search for gold and silver a royalty of two per cent. is exacted upon the gross amount of gold and silver mined.

Mill licenses.

Licenses to mill owners are issued under terms similar to the provisions of the Canada Gold Mining act of 1864 and of the Ontario act of 1868,

excepting that in the case of ores the product of a "free" mine* the royalty is paid to the owners instead of to the government. Provisions are also made for the forfeiture of gold and silver areas, and against unlawful entry upon crown or private land for mining purposes.

Forfeiture.

Of mines other than gold and silver the act provides :

Other minerals.

1. The commissioner may grant for one year licenses to search upon any lands not already applied for and to dig and explore for such minerals, upon a bond with sufficient sureties being given that in the event of entry being made on private lands recompense for damages will be made ; such license to cover any single tract of ground not exceeding five square miles in extent; the application to be accompanied with a fee of $20, and the land to be surveyed at the cost of the applicant ; and the license may be renewed for a second period of one year. The commissioner may also issue licenses to search for second rights over the same area to the number of not more than one for each square mile in the tract.

Licenses to search.

2. The holder of a license may at any time before its expiration select from the tract an area of one square mile for the purpose of working the mines and minerals therein, and make application to the commissioner for a license to work the same, accompanied with a fee of $50 ; and upon the survey being made at his cost he becomes entitled to a license to work the property.

License to work an area.

3. A license to work is made for a term of two years, which may be extended one year upon payment of an additional $25, and the holder is required to commence effective operations and carry them on in good faith to the end of the term ; and upon complying with the conditions of the license the holder becomes entitled to a lease of the premises on or before the termination of his license.

Conditions of procuring a lease

4. Leases are made for a term of twenty years, and are renewable for a period to extend not more than eighty years from the original date ; and in case it is shown that, by reason of the deficiency of mineral or other causes, an area of one square mile is insufficient to make a profitable mine the governor in council may by special order grant a lease for a second area of one square mile.

Term of a lease.

5. The owner, agent or manager of every mine is required to make quarterly returns to the commissioner of the quantity of mineral taken out, together with its probable use and destination, and the amount of royalty accrued upon it ; and also returns specifying the number of persons employed in the mine below and above ground, the different classes so employed, and the cost and description of all works carried on during the quarter, such returns to be sworn to by the agent or manager and one or more principal persons employed at the mine.

Returns to be made to the commissioner.

6. The royalties payable on ores and minerals are as follows : Coal, 9.7 cents per ton of 2,240 lb. ; copper, 4 cents per unit, that is, upon every one per cent. copper in each ton of 2,352 lb. of copper ore sold or smelted : lead, 2 cents per unit in each ton of 2,352 lb. of lead ore sold or smelted ; iron, 5 cents on every ton of 2,240 lb. of ore sold or smelted ; and on tin and precious stones, 5 per cent. on their value.

Royalties on ores and minerals.

BRITISH COLUMBIA.

The laws of British Columbia relating to gold and other minerals excepting coal were consolidated and amended in 1884, and they were again amended in some particulars in 1886, 1887 and 1888. The act is didided into eleven parts, relating to the following classes of subjects, viz : (1) Powers of gold commissioners and county court jurisdiction in mining cases and appeals ; (2) free miners and their privileges ; (3) registration of claims and free miner's general rights ; (4) nature and size of claims ; (5) bed rock flumes ; (6) drainage of mines ; (7) mining partnerships and limited liability ; (8) administration of the mining property of deceased miners ; (9) leases ; (10) ditches ;

The mining act of 1884.

*The words "free mine" refer to only one trifling matter. Some years ago, in order to encourage the putting up of quartz mills, it was provided that any person erecting a crusher in a locality less than ten miles from any other efficient crusher should be entitled to a lease of not less than ten mining areas free from royalty for 21 years. Under that provision a few crushers were erected upon conditions which entitled the owners to the free areas. The provision was repealed in the revision of the statute in 1884, but the reference to free mines had to be left in order to provide for the few areas that had been already acquired.

and (11) penal and miscellaneous clauses. A summary of the more important of these parts is given below:

Powers of gold commissioners.

1. A gold commissioner may sit as a judge in a mining court and hear and decide all cases coming before him, such as granting leave of absence to discoverers of new claims; laying over claims during scarcity of water; granting a miner or company absence for one year from a claim upon proving to the commissioner that work in cash, labor or machinery to the value of $1,000 has been put on the claim without a reasonable return in minerals; and affording protection against dangerous works; and in all mining disputes the judge is required when practicable to decide the question at issue upon the ground in dispute. Every county court may exercise within its limits all the jurisdiction of a mining court; but an appeal may be taken in any mining cause to the supreme court of the province.

Free miner's certificate.

2. Every person over sixteen years of age is entitled to hold a claim, and may obtain a free miner's certificate for one or three years upon payment therefor of $5 a year, issued by the gold commissioner or mining recorder. During the continuance of his certificate a free miner has the right to enter and mine upon any waste lands of the crown not lawfully occupied by any other person; and in the event of entering upon lands already occupied for other than mining purposes, full compensation is required to be made to the occupant or owner for any loss or damages he may sustain. But no one can be recognised as having any right or interest in a claim, or in case of disputed ownership, unless he is at the time of the dispute arising a free miner; neither is any person entitled to recover wages for labor performed as a miner in any claim unless he has had a free miner's certificate at the time of performing such labor, every person engaged in mining for minerals other than coal being required to take out a free miner's certificate.

Mining claims to be recorded.

3. Every mining claim located by a free miner must be recorded with the gold commissioner or mining recorder of the district in which it is situated within three days after the location thereof, if within ten miles of the office—an additional day being allowed for every additional ten miles. But in the case of auriferous land so situated that there is no gold commissioner or mining recorder in the locality, it is lawful for the miners to hold meetings and by two-thirds vote make rules consistent with the act for their good government, and appoint one of their number to issue free miner's certificates and enter records of the mining property. The title to claims is recognised according to priority of their registration, subject to the validity of the record, and transfers of claims to be enforceable must be in writing. The books of record are required to be open to public inspection free of charge, during reasonable hours, and certified extracts from them are receivable in any court as evidence. A free miner may hold at the same time any number of claims acquired by purchase, but only two claims by pre-emption in the same locality, subject to the laws as to record and occupation, and he may sell, mortgage or dispose of the same; he is also entitled in addition to hold one pre-emption claim on each hill, creek, ravine or bench. Saving as to claims held in fee simple, the interest of a free miner in his claim is deemed to be a chattel interest, equivalent to a lease, renewable, but subject to conditions of forfeiture. He is entitled exclusively to all the proceeds realised from the claim, provided that it is faithfully and not colorably worked, and the exclusive right of entry upon it except as authority may be given by the gold commissioner to adjacent claim-holders for the working of their own claims upon such terms as to him may seem reasonable. A claim is deemed to be abandoned and open to the occupation of any free miner when it has remained unworked for seventy-two hours by the registered holder, unless sickness or other reasonable cause can be shown, and every forfeiture is absolute.

Size of mineral claims, and right to follow veins.

4. The size of mineral claims, by which is meant claims containing any mineral except coal, in lodes or veins or rock in place, is 1,500 feet long by 600 feet wide, measured horizontally and marked by three posts along the centre line. The holders of such claims have the exclusive right of the surface included within the lines of their locations, and all the veins, lodes and ledges throughout their entire depth the top or apex of which lies inside the surface lines extended downward vertically, although they may so far depart from a perpendicular in their course downward as to extend outside the vertical *side*-lines of the surface locations; but the right of possession to the outside parts of veins is confined to such portions as lie between the vertical planes drawn downwards through the *end*-lines of the locations so continued in their own direction that the planes will intersect the exterior parts of the veins—saving that the owner of a vein which extends downward beyond the vertical lines of his claim cannot enter upon the surface of another's

claim. Where two or more veins cross each other priority of title governs as to ore or mineral within the space of intersection, right of way being allowed the holder of subsequent location for convenient working of his mine through the space of intersection; and where two or more veins unite the oldest or prior location takes the vein below the point of union, including all the space of intersection.

5. No free miner or company is entitled to hold, directly or in the name of any other person, more than one claim on the same lode or vein except by purchase, but may by pre-emption hold a claim in each separate ledge, lode or vein. The holder of a mineral claim may obtain a crown grant therefor by filing in the land office of the district an application showing under oath that a vein or lode has been found or exists within the limits of the claim of which the applicant is in undisturbed possession, together with a plat and field notes of the claim made by a surveyor acting under instructions from the commissioner of lands and works, posting a copy of the plat and notice of application for a grant on the land embraced in the plat previous to filing the application, and filing in the district land office an affidavit of at least two persons that the notice has been duly posted, together with a copy of the notice. It is then the duty of the government agent of the district to cause to be published at the cost of the applicant a notice of the application for sixty days in the official gazette and in any newspaper in the district, and post the notice in his office; and if the applicant file with the agent a certificate of the gold commissioner of the district that a sum of $500 has been expended in money or labor upon the claim, and at the end of the sixty days an affidavit showing that the plat and notice have been posted in a conspicuous place on the claim, and no adverse claim is filed, he becomes entitled to a grant from the crown. The grant is deemed to transfer the right to all minerals excepting coal in the land; but the land is subject to an annual tax of one dollar per acre, unless the owner can show to the satisfaction of the gold commissioner of the district that the sum of $200 has been expended thereon in labor or improvements in any year, in which case the tax is not levied for such year. Crown grants.

The other provisions of this act relate chiefly to alluvial mining and mining partnerships.

DOMINION OF CANADA.

No measure dealing specially with mining or mineral lands has been enacted by the parliament of Canada; but by sections 47 and 48 of the Dominion Lands act it is declared that lands containing minerals are to be disposed of in such manner and terms as are provided under regulations made by the governor in council, saving that no grant from the crown can be deemed to convey gold or silver in the lands unless they are expressly conveyed in the grant. The regulations at present in force were adopted October 5, 1887, and relate to all minerals of economic value except coal. The following summary refers to such of them as are applicable to Ontario: The Dominion government's mining regulations.

1. Any person may explore vacant lands not reserved for other purposes for minerals, but no location can be granted until actual discovery has been made of the vein, lode or deposit of mineral within the limits claimed. Lands which may be located.

2. Except for iron and petroleum, the extent of a location on veins or ledges of rock in place cannot exceed 1,500 feet in length by 600 in breadth, the surface boundaries to be four straight lines, and the boundaries beneath the surface to be the vertical planes in which its surface boundaries lie. Extent of locations.

3. Any person having discovered a mineral deposit may obtain a mining location therefor by staking or marking off the ground according to the regulations, and within sixty days filing with the land agent in the district a declaration under oath, setting forth the circumstances of the discovery and describing the locality and dimensions of the location, and paying to the agent an entry fee of $5. The agent's receipt authorises the claimant to take possession of and work the location, subject to renewal upon payment of the same fee from year to year for the term of five years, provided that during each year he shall expend at least $100 in actual mining operations on the location and furnish the agent a full statement of such expenditure under oath, corroborated by two reliable and disinterested witnesses. How mining locations may be obtained.

Conditions of purchase.

4. Any time before the expiry of five years the claimant may purchase the location, upon proof that he has expended not less than $500 in actual mining operations; the price for a location to be $5 per acre, cash.

Survey of locations.

5. In addition to payment of the price of the location the claimant is required to deposit with the agent $50 as payment to the government for survey of his location, when, upon receipt of the plans and field notes and approval thereof by the surveyor-general, the patent shall issue; or the claimant himself may procure a survey by a duly commissioned surveyor if on account of its remoteness the location cannot be surveyed by the government for $50, in which case the patent shall issue upon receipt of the plans and field notes and the claimant is entitled to return of his deposit. But failing to comply with any of the conditions of occupation during the period of five years, the right of the claimant shall lapse and the location shall revert to the crown.

Disputed claims.

6. Where the same location is claimed by two or more persons the right to acquire it depends on priority of discovery; but a person making a subsequent and independent discovery, and complying with the other conditions prescribed in the regulations, takes precedence of the first discoverer if the latter has failed to comply with the conditions; and not more than one location can be granted to any individual upon the same lode or vein.

Mill claims.

7. Where land is used for milling purposes, or for other purposes incidental to mining operations, it may be applied for and patented in the same way as a mining location; but it cannot exceed five acres in extent and must be paid for at the same rate as a mining location.

Petroleum and iron locations.

8. The minister of the interior may grant a location for mining petroleum or iron not exceeding 160 acres, being a square bounded by due north and south and east and west lines; but in the event of other minerals being found upon the property the claimant's right becomes restricted to the area for other minerals, and the rest of the location reverts to the crown.

Rival claimants.

9. In a case where two or more persons apply for any mining location, neither of whom is the original discoverer, the minister of the interior, if he sees fit to dispose of the location, will either invite their competitive tenders or put it up to public auction as he may deem expedient.

Assignment of right to purchase.

10. An assignment of the right to purchase a location is permissible upon compliance with certain requirements, and payment to the land agent of a registration fee of $2.

Superintendent of mines to hear disputes.

11. The superintendent of mines is authorised to hear and determine all disputes in regard to mining property within his district, subject to appeal by either of the parties to the commissioner of Dominion lands.

Mining districts.

12. The minister of the interior may establish mining districts and declare their boundaries, and, when from the report of the director of the Geological Survey or from other information he has reason to believe that there are mineral deposits of economic value in such districts, he may direct locations to be laid out and may sell them for cash, either privately to applicants who in his opinion are able and intend in good faith to work the locations, or by public auction and tender. The minister may also grant to any person holding and actively developing a location a second one of equal area, providing it is shown that the vein or lode being developed will probably extend outside of either of the vertical planes forming the side boundaries of the first location before it has reached a depth at which it cannot be profitably mined.

Stone quarries

13. Persons desirous of obtaining quarries for stone on vacant lands may do so under the regulations, either by purchase of the land or by payment of a royalty not exceeding five per cent. on the sales of the product.

Protection of mining works.

14. The minister is empowered by the regulations to summarily order any mining works to be so carried on as not to endanger the safety of the public, or interfere with any public work or highway, or any mining property; and he may order any abandoned works to be either filled up or guarded at the cost of the parties who may have constructed the same.

Prevention of malicious injury to mines.

In addition to the regulations, provision is made by sections 28-31 of chapter 168, R. S. C. 1886, for the prevention of malicious injury to mines, whether by setting fire to the premises, filling up or otherwise damaging a mine or well, or pulling down or obstructing any machinery or works of a mine; the person so offending being guilty of a felony, and liable to imprisonment for terms not exceeding seven to fourteen years according to the nature of the offence.

UNITED STATES.

The object of the earliest congressional legislation on public mineral lands in the United States was to secure a revenue therefrom, and to this end, as appears by Copp's United States Mineral Lands, the system of leasing the lead and copper mines was adopted in 1807. This system was pronounced a failure after a trial of forty years, and in 1846 the mines were offered for sale, with a preference right in those who had leases or were in occupation. Since 1866 the object of the legislation has been to prevent the disposal of mineral lands to states and railroads, or in large quantities to individuals. Exploration for minerals is encouraged, and no efforts are used to compel miners to expend money for securing government title. "The mining law of May 10, 1872," says Copp, "is essentially the poor man's law, and has been the source of incalculable wealth to the country, and indirectly of vast value to the government."

Early legislation.

The poor man's mining law.

By a congress ordinance of 1785 one-third part of all gold, silver, lead and copper mines was reserved to be sold or otherwise disposed of as congress might thereafter direct, which ordinance continued in force until 1789.

Minerals reserved.

By an act of 1807 the leasing of lead mines for a period not exceeding five years was authorised, and this system was continued until 1846. In nearly all the pre-emption acts prior to 1841 minerals were reserved, but the act of that year excluded from its operation all lands on which were situated any known salines or mines. The acts of 1846 and 1847 authorised the sale of mineral lands in several of the states and territories, thus acknowledging the failure of the lease system. In the acts relating to California special care seems to have been taken to prevent the appropriation of mineral lands by settlers, and the Donation act of Oregon excluded such lands from its operation.

The leasing system.

In the earlier grants to aid railways, minerals are not mentioned in terms, but a general clause was inserted excepting all lands reserved for any purpose by act of congress. The acts of 1862 and 1864, which donated nearly 100,000,000 acres to railroad corporations, gave the coal and iron lands within their limits, but excepted other mineral lands from the grants, and in this form such lands are still excluded from railroad grants in the mining states and territories.

Grants of lands to railways.

Digging for minerals on the public domain prior to the act of 1866 was a trespass, entitling the government to damages, and was such a waste as could be restrained by injunction. But by this act the mineral lands of the United States were thrown open to exploration and occupation, and it is no longer a trespass to dig ore or engage in mining operations on the public domain.

Free exploration secured.

The act of 1846 authorised the sale of mineral lands in Illinois, Arkansas, Wisconsin and Iowa, but still excepted the lead mines from pre-emption. The reserved mineral lands of Missouri had been offered for sale a short time before, and those of Michigan in the following year. In 1850 mineral lands in Michigan were disposed of in the same way as agricultural lands, subject to the same minimum rights of pre-emption. In the states of Missouri, Kansas, Minnesota, Michigan and Wisconsin there is an express direction by the

Mineral lands reserved except in special cases.

law that all lands shall be sold as agricultural lands, but the general provision is that "in all cases lands valuable for minerals shall be reserved from sale, except as otherwise expressly directed by law."

Act of 1866.

The act of 1866 provided as follows:

Citizens may explore mineral lands of the public domain.

1. Mineral lands of the public domain, surveyed and unsurveyed, are declared to be free and open to exploration by all citizens of the United States and those who have declared their intention to become citizens, subject to regulations prescribed by law, and to local customs or rules of miners in the district.

Filing a claim.

2. Whenever any person claims a vein or lode of quartz or other rock in place bearing gold, silver, cinnabar or copper, having previously occupied and improved the same according to the local customs or rules, and having expended in actual labor and improvements upon it an amount of not less than $1,000, and in regard to whose possession there is no controversy or opposing claim, he may file in the local land office a diagram of the tract and become entitled to enter the tract and receive a patent therefor, together with the right to follow such vein or lode, with its dips, angles and variations, to any depth, although it may enter the land adjoining, which land adjoining shall be sold subject to this condition.

Conditions of obtaining patent.

3. Upon the filing of the diagram and posting a copy in a conspicuous place on the claim, with notice of intention to apply for a patent, the register of the land office shall publish a notice thereof in a newspaper and post a notice in his office for ninety days, after which if no adverse claim is filed it shall be the duty of the surveyor-general, on application of the party, to survey and make a plat of the premises, and upon payment of $5 an acre with cost of survey, etc., and evidence that the diagram and notice have been posted on the claim for ninety days, the register shall transmit to the general land office the plat, survey and description, when a patent shall issue. But the plat, survey and description shall in no case cover more than one vein or lode.

Size of locations.

4. No location shall exceed 200 feet in length along the vein for each location, with one additional claim for discovery to the discoverer of the lode, with the right to follow the vein to any depth and with a reasonable quantity of surface for convenient working of the same; but no person may make more than one location on the same lode, and not more than 3,000 feet may be taken in one claim by any association of persons.

Sections 5 to 11 made various provisions as to rights acquired with claims, and as to reserved mineral lands occupied for agricultural purposes.

The Act of 1872.

The mining laws at present in operation are based on the act of 1872, revised and consolidated in the following year. Following is a summary of their provisions:

Mineral lands reserved.

1. Lands valuable for minerals are reserved from sale, except as otherwise expressly directed by law.

Open to exploration and purchase by citizens.

2 All valuable mineral deposits in surveyed or unsurveyed lands are declared to be free and open to exploration and purchase, and the lands in which they are found to occupation and purchase by citizens of the United States and others who have declared their intention to become such, under regulations prescribed by law, and to the local customs or rules of miners in the several mining districts so far as these are applicable and not inconsistent with the laws of the United States.

Extent of mining claims on veins or lodes.

3. A mining claim on a vein or lode of quartz or other rock in place bearing gold, silver, cinnabar, lead, tin, copper or other valuable deposits, whether located by one or more persons, may not exceed a length of 1,500 feet along the vein by a breadth ranging from 25 to 300 feet on each side of the middle of the vein at the surface, the end lines to be parallel to each other; but no location of a mining claim can be made until the discovery of the vein or lode within its limits.*

Proof of citizenship.

4. Proof of citizenship in the case of an individual may consist of his own affidavit; in the case of an association of persons unincorporated, of the affidavit of their authorised agent; and in the case of a corporation organised under the laws of of the United States, by a certified copy of their charter or certificate of incorporation.

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* The regulations made under the act state that the object of this provision "is evidently to prevent the appropriation of presumed mineral ground for speculative purposes to the exclusion of *bona fide* prospectors, before sufficient work has been done to determine whether a vein or lode really exists."

5. So long as they comply with the laws and regulations locators have exclusive right of possession of all the surface included within the lines of their locations, and of all veins, lodes and ledges throughout their entire depth, the top or apex of which lies inside of such surface lines extended downward vertically, although such veins may so far depart from a perpendicular in their course downward as to extend outside the vertical *side*-lines of the surface locations, provided that right of possession to the outside parts of veins are confined to such portions as lie between vertical planes drawn downward through the *end*-lines of the locations so continued in their own direction that the planes will intersect the exterior parts of the veins; but the locator or possessor of such a vein or lode has no right of entry upon the surface of a claim owned or possessed by another. Locators' right of possession and enjoyment.

6. Where a tunnel is run for development of a vein or for discovery of mines, the owners have the right of possession of all veins within 3,000 feet from the face of the tunnel on the line thereof, not previously known to exist, to the same extent as if discovered from the surface; and locations on the line of a tunnel of veins not appearing on the surface, made by other parties after commencement of the tunnel, are invalid; but failure to prosecute work on the tunnel for six months is to be considered as an abandonment of the right to all undiscovered veins on the line of the tunnel. Rights of owners of tunnels.

7. The miners of each district may make rules and regulations not in conflict with the laws of the United States or of any state or territory in which the district is situated, governing location, manner of recording, and amount of work necessary to hold a mining claim, subject to specified requirements, viz: the location to be distinctly marked on the ground, all records of claims to contain names of locators, date of location and description to identify the claim. Regulations made by miners.

8. In proceeding to obtain a patent for land claimed and located for valuable deposits any party who has complied with the terms of the act may file in the proper land office application for a patent under oath showing compliance, with a plat and field-notes of the claim showing its boundaries, post a copy of the plat and notice of application on the land previous to filing the application, file an affidavit of at least two persons that the notice has been duly posted and file a copy of the notice in the land office; and the register is thereupon required to publish a notice of the application for sixty days. The claimant is also to file with the register a certificate of the United States surveyor-general that $500 worth of labor has been expended on improvements made on the claim, that the plat is correct, etc., and at the end of sixty days he is to file an affidavit that copies of the plat and notice have been posted during the period of publication; when, if no adverse claim has been filed, it is to be assumed that the applicant is entitled to a patent upon payment of $5 per acre. How patents for mineral lands are obtained.

9. The next section deals with the case of an adverse claim, and provides that the claim must be filed on the oath of the person making it, and that proceedings to determine the question of right must be taken in a court of competent jurisdiction within thirty days of filing the claim. Proceedings to be taken on an adverse claim.

10. The description of vein or lode claims upon surveyed lands must designate the location of the claim with reference to the lines of the public surveys, but need not conform therewith; but where a patent is issued upon unsurveyed lands the surveys when made must be adjusted to the boundaries of the patented claim, without interfering with or changing the location. Description of vein or lode claims.

11, 12, 13, 14, 15, 16 and 17 deal with claims under former laws, and with placer claims, the latter of which are limited to an area of 160 acres, but may be sub-divided into areas of 10 acres. Other claims.

18. The expenses of the survey of vein or lode claims and the survey and sub-division of placer claims into smaller quantities than 160 acres, together with the cost of publication of notices, must be paid by the applicants; but they are at liberty to employ any United States deputy surveyor to make the survey. The surveyor-general has power to fix the maximum charges for survey, as well as the newspaper rates for publication of notices; and a sworn statement of all charges and fees is required to be filed by the applicant with the register, to be transmitted with all other papers in the case for the information of the commissioner of the general land office. Surveys.

19. Where two or more veins intersect or cross each other priority of title governs, the prior location being entitled to all ore or mineral contained within the space of intersection, but with right of way to the subsequent location through the space of intersection for the purpose of convenient working of the mine; and Title in cross or united veins.

where two or more veins unite the oldest or prior location takes the vein below the point of union, including all the space of intersection.

Non-mineral land for mining or milling purposes.

20. Where non-mineral land not contiguous to a vein is used by the proprietor of the vein for mining or milling purposes it may be included in the application for the vein and patented therewith, but so as not to exceed five acres, at $5 per acre.

Additional land districts.

21. The president is authorised to establish additional land districts and appoint the necessary officers under existing laws, whenever this is deemed necessary for the public convenience.

Mineral lands in certain states excepted.

The provisions of this act do not apply to the mineral lands in Michigan, Wisconsin and Minnesota, which are declared free and open to exploration and purchase according to legal sub-divisions; and such lands are required to be offered for public sale in the same manner, at the same minimum price and under the same rights of pre-emption as other public lands.*

COLORADO.

Size of vein.

In Colorado the length of a lode claim cannot exceed 1,500 feet along the vein, and in four counties specified the width cannot exceed 75 feet, nor in other counties 150 feet on each side of the centre; but each county may at a general election determine upon a width not exceeding 300 feet on each side of the centre of the vein or lode. The discoverer is required to record his claim in the office of the recorder of the county in which it is situated within three months from the date of discovery; but before filing the location certificate he must locate the claim by sinking a discovery shaft upon the lode to the depth of at least ten feet, post a notice of the discovery upon the claim and mark its boundaries; and no location certificate may claim more than one location. The location is construed to include all lodes and ledges throughout their entire depth whose top or apex lies inside the surface lines extended downward vertically, with such parts as dip beyond the side lines of the claim, but not such parts as extend beyond the side lines in any other manner than by the dip of the lode; and every miner has the right of way across all other locations for the purpose of hauling quartz from his claim.

Recording a claim.

Discovery shaft.

Location.

Right of way

DAKOTA.

Size of claim.

In Dakota the length of a lode claim may not exceed 1,500 feet and the width is fixed at 150 feet on each side of the centre of the vein; but each county may by a majority of votes cast at a general election determine the width, ranging from 25 to 300 feet on each side of the centre of the vein. The discoverer of a claim must record his claim in the office of the register of deeds of the county within twenty days from the date of discovery, but before filing the location certificate he must locate the claim by sinking a discovery shaft sufficient to show a well defined mineral vein or lode, post a notice of discovery on the claim and mark its surface boundaries. The provisions respecting the right to follow a vein are the same as in Colorado, and no location certificate can claim more than one location, whether made by one or several locators. Any person who performs labor upon a mine, at the request of the owners of the property or their agents, or who furnishes material or apparatus therefor, acquires a lien upon the property to secure payment of his claim.

Claim must be recorded.

Discovery shaft.

Laborer's lien.

* An act of 1876 also excludes from the operation of the mining law lands in the states of Missouri and Kansas, and declares that all lands in these states shall be subject to disposal as agricultural lands.

MICHIGAN.

The property in all mines of gold and silver and all mines of other metals or minerals which are known to contain gold and silver in any proportion was vested in the people of the state of Michigan by a statute of 1846, but this right is not enforceable against any citizen of the state in whom the fee of the soil containing any such minerals is fully vested by purchase from or under the state or general government. All primary school lands and lands located by the state for internal improvement purposes, known to contain mines or minerals, were by the same act reserved from sale pending such regulations as the legislature might prescribe, and a tax of four per cent. in lieu of all other state taxes was authorised to be imposed and collected upon the product of all mines in the state excepting iron ores, the tax upon which was limited to two per cent. By a subsequent act of the same year the state land office was authorised to lease the lands reserved as above in quantities not less than 40 acres, for a period not exceeding three years, but before they could be leased upon private application they had first to be exposed to lease at public auction to the highest bidder. The lands so leased were subject to a rate of not less than four per cent. upon the average yield and value of all minerals taken from the lands, and such further annual rent in advance as the commissioner was able to obtain for them; but the lands leased under those provisions were not subject to any other taxes. By an act of 1863 all swamp and primary school lands in the upper peninsula withheld from market as mineral lands, except such sections as the governor may select and reserve, are open for sale in the same manner as other lands of the same class in the state. But before these lands are offered for sale the governor may cause an examination to be made of them by agents appointed for the purpose, whose duty it is to appraise each tract, and upon receiving their report the governor and state treasurer fix a minimum price at which each tract may be sold, whereupon the commissioner of the land office offers the land at public sale. Every corporation or association engaged in mining is required to pay a tax of seventy-five cents on each ton of copper and one cent on each ton of iron ore annually in lieu of all other state taxes except taxes on capital stock. An act of 1877 provides for the appointment of a commissioner of mineral statistics for the state, whose duty it is to make an annual report setting forth in detail the mineral statistics of the year, and the progress and development of its mining industries. It is also his duty to make such geological surveys as are needed for carrying out the purposes of the act, to observe and record by maps and plans especial facts which may be developed in the course of mining and exploration, and to make a collection of typical suites of specimens to be placed at the disposal of the state board of education for distribution among the educational institutions of the state. All corporations or individuals engaged in mining are required to make such reports under oath as to product and other matters as the commissioner may ask for, and it is his duty to report such information for each corporation or individual to the auditor-general as the basis for computing the specific taxes against each owner or owners of a mining property.

Property in gold and silver mines.

Mining lands reserved from sale.

Trial of the leasing system.

The law changed to sales of lands in fee simple.

Taxation.

Mining statistics

MONTANA.

Claim to be filed and recorded.

In Montana the person who discovers a mining claim on a vein or lode is required within twenty days to make and file in the office of the recorder of the county a written statement on oath describing the claim as provided by the laws of the United States; and to entitle him to so record he must have discovered a vein or crevice of quartz or ore with at least one well-defined wall. The extent of a claim is the same as is provided in the United States law.

NEVADA.

Minerals reserved.

In Nevada all timber and mountainous lands granted by the United States to the state are sold with a reservation of the minerals; and whenever any minerals may be discovered on such lands after they have been sold and patented the state has the right to convey mining claims thereon in the same manner and of the same amount in any one claim as is the law and practice of the United States; and the right of way over such timber and grazing lands, being reserved, is granted to the purchaser of any mining claim.

NEW YORK.

Minerals reserved.

In New York all mines of gold and silver, all mines of other metals discovered upon lands owned by aliens and all mines owned by citizens the ore of which upon an average contains less than two equal third parts in value of copper, tin, iron and lead or any of those metals, are the property of the people of the state in their right of sovereignty; as also are all mines and minerals discovered on the public lands. All mines other than of gold and silver discovered on any lands owned by a citizen the ore of which contains on an average two equal third parts or more in value of copper, tin, iron and lead, or any of those metals, belong to the owner of the land.

Discoverers' exemption.

Every person making a discovery of a mine of gold or silver in the state is exempted from paying to the state any part of the ore, produce or profit of the mine for twenty-one years, but no person discovering such a mine is permitted to work it until he gives notice to the secretary of the state describing particularly the nature and situation of the mine; and after the expiration of the term of twenty-one years the discoverer or his legal representatives shall be preferred in any contract for the working of the mine.

Consent to enter private land is necessary

No person can enter on or break up the land of any other person without his consent in writing, nor upon any public land without the consent of the commissioner of the land office; but in case a person discovers a mine and forms a corporation to work it, if consent cannot be obtained by agreement, or by reason of legal disability of the owner of the land, proceedings may be taken by the company in the supreme court of the state, when the court may appoint three comissioners to enquire into the matter, fix the damages and report to the court all information in the matter as directed, when in the discretion of the court an order may be made either denying the petition or granting it—in the latter case determining the quantity of land necessary for working the mine, the damages to the property by taking possession of it, and the annual rent or compensation to be paid to the owner or occupant so long as the use of it may continue. Thereupon the company in whose favor the order is made, upon payment of damages and entering into an agreement, to

be approved by the court, to pay the annual rent, have the right to enter upon and use the land set apart by the order, so long as they or their assignees work the mine and pay the annual compensation. But the New York statute is practically a dead letter, as no such mines as those referred to exist in the state.

OREGON.

In Oregon any person or company of persons establishing a claim on a quartz lead for the purpose of mining it are allowed to hold the land or vein, with all its dips, spurs and angles, for the distance of 1,500 feet in length and 300 feet in width on each side of the lead or vein. Any person may hold one claim by location upon each lead or vein, and as many by purchase as the local laws of the miners in the district where the claims are located may allow; and the discoverer of a new lead or vein not previously located upon may be allowed one additional claim for his discovery. Every person after establishing a claim or claims is required to do $50 of work on every claim each year, under penalty of forfeiture.

Size of claim.

Second claim allowed to a discoverer.

SOUTH CAROLINA.

In South Carolina royalty is collected by the agricultural bureau of the state, authorised by the state law, from persons or companies who mine or dredge phosphate under any law, license or charter of the state, estimated upon the crude rock; such royalty to be not less than $1 per ton, nor greater than 25 per cent. of the market value of the crude phosphate.

Royalty on phosphate.

UTAH.

In Utah any citizen of the United States, or any person who has declared his intention to become a citizen, who discovers any mineral deposit is entitled to one claim thereon by right of discovery, and one by right of location; but no person is entitled to more than one claim by right of location on any one lead or lode; and any person who performs any work or labor on a mine, or furnishes material therefor, under contract with the owner, is entitled to a miner's lien upon all interest, right and property in the mine.

Right of discovery.

Miner's lien.

WISCONSIN.

In Wisconsin certificates of sale of public lands do not bestow the right to take the minerals; the written consent of the commissioner of public lands must be obtained. A license or lease made to a miner is not revocable by the maker after a valuable discovery has been struck unless the miner should forfeit his right by negligence such as establishes a forfeiture according to mining usages. The discovery of a crevice or range containing ores entitles the discoverer to the ores, subject to the rent due his landlord, before as well as after the ores are separated from the freehold; but the miner is not entitled to recover any ores from the person digging on his range in good faith, and known to be mining thereon, until he has given notice of his claim. In case of conflicting claims to a crevice or range bearing ores the court may continue any action to enforce a claim, or grant any necessary time for the purpose of allowing parties to prove up their mines, and may appoint a receiver under whose directions the work may be carried on and pay the rent or other necessary expenses; and the usages or customs among miners may

Minerals reserved.

Leaseholder's right.

Conflicting claims.

be proved in explanation of mining contracts to the same extent as usage may be proved in other branches of business. A miner who conceals or disposes of any ores for the purpose of defrauding his lessor of his rent, or who neglects to pay rent on ores raised by him for three days after claim is made, thereby forfeits all right to his mines or range; and in case he neglects to work his mines according to the usages of miners without reasonable excuse, he also forfeits his mines. Every person or corporation engaged in mining may, when necessary, convey water over or through the land of any adjoining owner, and, in case of failure to agree upon the damages for right to so conduct the water, commissioners may be appointed to appraise the amount, but with right of appeal to the circuit court by either of the parties. Every smelter and purchaser of ores and minerals is required to enter in a book as ores or minerals are received a record showing date of receipt, name of person from whom purchased, name of person by whom hauled and delivered, name of owner of the land from whom the ore was obtained, or, if not known, some distinct description of the land, and such book must be open to all persons at reasonable times for inspection and taking extracts; and for failure to keep such a book or make such entries, or for making false entries, or refusal of permission to inspect the book or take extracts from it, the person offending is liable to a penalty of $10 for each offence, and each day of such failure or refusal is to be deemed a distinct and separate offence.

Forfeiture.

Water rights.

Smelters and dealers are required to keep record books.

WYOMING.

In Wyoming the area of a claim is limited to 1,500 feet along the lode or vein and 300 feet on each side of it, measured from the centre of the discovery shaft. The discoverer of a lode is required to record his claim in the office of the recorder of deeds of the county in which the claim is situated within three months from the date of discovery; but before filing a location certificate he is required to designate the location by sinking a shaft upon the lode or fissure to a depth of ten feet, to post a notice of discovery upon the claim, and to make and mark the surface boundaries; and he is allowed a period of ninety days from the date of discovering the vein in which to sink a shaft thereon. Any person who defrauds, cheats or swindles another party by "salting" or placing in a mine any genuine metals which are designed to cheat and deceive others for the purpose of gain, whereby others are deceived and injured, is guilty of a felony and liable to a penalty of $50 to $5,000, or imprisonment for not less than thirty days nor more than three years, or to fine and imprisonment in the discretion of the court. The lien laws of Wyoming are similar to those of Utah.

Size of claim.

Claim to be recorded.

Discovery shaft.

"Salting" is made a felony.

In most of the states aliens are privileged to hold land in the same manner and to the same extent as citizens, and in most of the states also the amount of real estate which corporations may hold is only limited by the restriction of the general phrase, "as much as may be necessary for the carrying on of their business." Michigan allows no corporation to hold more than 50,000 acres. Maryland restricts the amount to 1,000 acres in one specified county and 500 acres in all other counties. In West Virginia companies established to mine and manufacture lead, iron or copper ore may hold 10,000 acres for each charcoal blast furnace and 3,000 acres for every

Right of holding real estate.

other furnace. Massachusetts places the limit at three-fourths of the capital stock in value.

Where the capital stock of mining corporations is taxed reports are required, but in many states fuller details are required for the benefit of shareholders and the public. In Connecticut and Massachusetts a company failing to make an annual report for two consecutive years becomes thereby dissolved. In New Hampshire a full report must be made to the town clerk and filed with the secretary of the state, and neglect to make such a statement involves the directors in responsibility for all debts. In New York an annual report of business affairs must be published in a newspaper and filed with the clerk of the county court, failure to do which renders the trustees liable for all debts contracted before it is made. In Michigan the corporations must when called upon by the commissioner of mineral statistics report the number of gross tons of copper and iron mined and shipped, of mineral coal produced and of pig iron manufactured, together with statistics of production of all other minerals or ores. Reports.

Laws to regulate the working of mines and provide for the health and safety of miners have been enacted in almost all the states in which mining operations are carried on; and in a few states, as Illinois, Indiana, Ohio, Pennsylvania and West Virginia, their requirements are very comprehensive. Regulations for the health and safety of miners

GREAT BRITAIN AND IRELAND.

In England the owner of a freehold is ordinarily entitled to all the minerals underground, except gold and silver; but under statute law the ownership of minerals may be severed from that of the surface.* Mines of gold and silver belong to the crown, but gold and silver extracted from ores of the base metals are not so claimed. A statute of 1688 provided that no mine of copper, tin, iron or lead in England and Wales should thereafter be adjudged or taken to be a royal mine, although gold or silver might be taken out of it; and by an amending act of 1694 the right of private ownership was further enlarged and safeguarded. "All and every person or persons, being subjects of the crown of England, bodies politic or corporate, that now are or hereafter shall be owner or owners, proprietor or proprietors of any mine or mines . . . shall and may hold and enjoy the said mine or mines and ore, and continue in the possession thereof, and dig and work the said mine or mines or ore, notwithstanding that such mine or mines or ore shall be pretended or claimed to be a royal mine or mines; any law, usage or custom to the contrary notwithstanding." But the same act gave the sovereign a pre-emptive claim on all ores mined (except tin in the counties of Devon and Cornwall) for a period of thirty days after they have been raised, at prices fixed in the act,† and in default of payment of such prices "it shall and may be lawful for the owners and proprietors of the said mine or mines Gold and silver reserved. Right of private ownership. Pre-emptive claim on ores given to the sovereign.

*By section 19 of the act of 1877, amending the law relating to leases and sales of settled estates, it is provided that "On any sale of land any earth, coal, stone or mineral may be excepted, and any rights or privileges may be reserved, and the purchaser may be required to enter into any covenants or submit to any restrictions which the court may deem advisable."

† For all ore washed, made clean and merchantable the following rates were fixed: Copper, £16 per ton; tin, 40s. per ton; iron, 40s. per ton; and lead, £9 per ton; but by an act of 1815 the pre-emption price of lead was made £25 per ton, owing to the increased cost of mining the ore.

wherein such ore is or shall be found to sell and dispose of the said ore to his and their own uses; any law, statute or custom to the contrary notwithstanding." And that act is still a law in England. Local customs, now regulated by acts of parliament, are observed in several districts, as in Derbyshire, the Forest of Dean, and the counties of Cornwall and Devon.

Local customs.

The working of mines in the United Kingdom is controlled by five acts of parliament, the most important of which is the British Metalliferous Mines Regulation Act, 1872. Under this act no boy under twelve years of age and no girl or woman of any age can be employed in a mine below ground, and no boy of twelve to sixteen years of age can be employed below ground for more than fifty-four hours per week or more than ten hours in any one day; and no male of less than eighteen years of age can be employed in connection with the engines or other machinery of a mine; nor must wages be paid to any person employed in or about a mine at or within a public house for the sale of spirituous or fermented liquor, or at any place contiguous to such house. Other provisions of the act require that reports be furnished the inspector of a mining district in relation to (1) the quantity of mineral sold or produced from each mine and the number of persons employed at it, below and above ground respectively, for each calendar year; (2) accidents or loss of life to any person employed about a mine from explosions of gas, powder or steam boiler, or from any cause whatever; and (3) the commencement, abandonment, discontinuance or recommencement of work on a shaft of any mine, or of change in the name of owner, agent or officers. And in the case of a mine being abandoned or discontinued, the owner or other person interested in the property is required to securely fence it for the prevention of accidents, and to furnish the secretary of state with an accurate plan of the workings. The act also provides for inspection, arbitration and inquiries into the causes of accidents, rules for the management of mining works with a view to the safety and health of employés, and penalties for offences under the act. An amendment of 1875 requires the owner or agent of every mine to send to the inspector of the district by the 1st of February in each year a return specifying for the year ending the preceding 31st December the quantity in statute weight of the mineral dressed, of the undressed mineral which has been sold, treated or used during the year, the number of persons ordinarily employed, etc.

How mining operations are controlled.

Statistics.

Inspection.

NEW ZEALAND.

The New Zealand mining act of 1886, as amended by the three amending acts of 1887 and 1888, consists of 318 sections, and the regulations under the act number 257.* Following is a summary of the chief provisions of the act:

Laws and regulations.

1. Any portion of the colony may be constituted a mining district by proclamation of the governor, with such boundaries as may be assigned to it, and any mining district may also be abolished by proclamation.

Mining districts.

* An act to regulate the granting of coal mines leases and to make better provision for the regulation and inspection of coal mines was passed in 1886, as was also an act to consolidate and amend the law for the incorporation and winding up of mining companies. The latter extends and applies only to companies formed for mining purposes other than mining for coal.

2. Any of the crown lands within or outside a mining district may be set apart for mining purposes exclusively by the minister of mines; and upon such reserve being made in the neighborhood of any place where mining operations are carried on the lands cease to be crown lands and are not capable of alienation in any way, saving for mining purposes, without the consent of the minister. Mineral lands.

3. The officers who, under the minister, manage the mining affairs of the colony are (1) a receiver of gold revenue, to whom is paid all rents, royalties and fees in his district; (2) a mining registrar to carry out the provisions of the act respecting the registration of any claim held under the provisions of the act, or any sale, lease, surrender, etc., of a claim; (3) one or more inspectors, whose duty it is to see that the provisions of the act are carried out and to visit and inspect mines and all machinery used therein. Officers.

4. All lands alienated from the crown since 1873, or which may hereafter be alienated (except lands alienated expressly for mining purposes) are liable to be resumed by the government for mining purposes on payment of full compensation to the licensee, lessee or owner of the fee simple for the value, other than auriferous or argentiferous, of the lands and improvements so resumed, and the persons upon whose application the government has taken action have for thirty days after the resumption the priority of claim to occupy the land or any part of it for mining purposes. Or the lands may be resumed by direct action of the government without petition or application. Lands may be resumed by the government for mining purposes.

5. Crown lands in a mining district may be at any time withdrawn from the district by proclamation and leased for agricultural purposes for a period of seven years, but if such lands are afterwards proven to contain any metal or mineral the lease may be terminated at a month's notice, compensation for improvements being allowed. Lands in a mining district may be leased for agricultural purposes.

6. Any person applying for it and paying five shillings in advance may obtain a miner's right authorising him for twelve months to mine on crown lands in any part of the colony not subject to agreement with the natives; and any number of miner's rights may be issued to the same person, entitling him to occupy a corresponding number of claims, provided that in respect of each claim at least one person is employed, who need not be the holder of the miner's right. Similarly a number of persons may unite and procure a consolidated miners' right, which may be held by a manager or trustee, upon payment of a sum proportional for all the members to that required of one member. Miner's right

7. Every holder of a miner's right is entitled to enter upon any crown land to search for gold and take possession for mining purposes of as many parcels of land as the regulations permit, and of such quantity and dimensions as the regulations direct; and he is entitled to exclusive possession of the parcel as long as he requires it for mining purposes, and the claim may be registered. Privileges conferred by a miner's right.

8. Every claim from and after the day it has been marked out and registered must be continuously worked from day to day by the number of men prescribed by the regulations (saving that ten days grace is given to the owner of a quartz claim), and upon failure to comply with this requirement proceedings may be taken by any person to declare the claim forfeited. Claims must be worked

9. Claims of greater area than the regulations fix may be granted by the warden, with the consent of the minister, for the purpose of carrying on mining operations under circumstances of extraordinary difficulty, or involving the expenditure of considerable sums of money, or for the encouragement of enterprise in prospecting new ground, or as a reward for the discovery of new workings. Special claims.

10. The owner of a claim who desires to obtain a license for the land comprised in it, or any other person who desires to obtain a license for occupation of land under the act, must lodge an application at the warden's office, where it is recorded in the order in which it is received, and deposit with the receiver of revenue such sum for survey, etc., as the regulations require, and a further sum of £5 in respect of each application; and after deducting the first year's rent and the cost of survey, advertising and other expenses, the balance of the deposit is paid back. The warden will fix a day of hearing, and may grant or refuse a license. Licensed holdings.

11. The principal conditions upon which every license is held are (1) that the licensee must pay rent at the rate of 10s. per acre during the first three years of the term, of 15s. for the succeeding two years, and of 20s. for the remainder of the term; (2) that he must carry on mining operations in an efficient manner and employ at least as many competent men as the regulations require; and (3) that he is liable to pay royalty on all other metals or minerals which may be found in the land other than such as he is authorised to mine under the license. The licensee Conditions of licenses

may at any time surrender his license in whole or part, and upon the surrender being endorsed by the warden the rental is proportionately reduced, but no licensee is entitled to make a surrender in part more than twice during the currency of his license.

Right of a licensee.

12. Every license to work a gold mine gives the licensee exclusive right to dig and mine for gold and silver on the land for a time not exceeding twenty-one years, but no licensed holding under one license can exceed such area as may be prescribed.

Prospecting licenses.

13. The governor may issue a prospecting license to any person authorising him to search for any metal or mineral on crown lands outside the limits of any mining district and to the holder of such a license who makes a discovery outside a mining district, he may grant a lease of an area of land for mining purposes not exceeding double the quantity which might be held as a claim or licensed holding in the nearest mining district, but such lease cannot be for a longer term than twenty-one years.

Protection of private landowners.

14. Any person who knowingly mines or employs any person to mine for gold on land belonging to a private individual without the consent of the owner is treated as if he were not the holder of a miner's right, and may, in addition, be proceeded against by the owner for damages.

Other provisions.

The act of 1887.

Other provisions of the act relate to water rights and races, forfeitures, and the regulations of mines. The latter are very stringent, and appear to carefully guard the rights and interests of mine-workers. Ample provision is also made for the administration of justice by the constitution of a warden's court in each mining district. The amendment act of 1887 provides that the warden may grant mineral licenses to occupy any crown lands within a mining district for the purpose of mining metals or minerals other than gold, silver and coal, subject to the following conditions :

Area, rent and royalty.

1. The area comprised in a mineral license is not to exceed 320 acres, and the term for which it is granted must not exceed twenty-one years.

2. The rent is 2s. 6d. per acre, payable in advance.

3. The royalty on all minerals raised cannot be less than 2 or more than 4 per cent. of their value at the pit's mouth ; but in case the amount of royalty exceeds the sum paid as rent, the rent charge ceases.

4. No mineral license entitles the holder to mine or dig for gold or silver, and if either of those metals or ore containing them is found within the area comprised in the license the land on which gold and silver are found must be taken up as a licensed holding under the act.

Regulations.

Size of claims.

Under the regulations the area of ground that may be held under any license for gold mining purposes cannot exceed thirty acres, and may be in any form providing the length does not exceed twice the breadth. The size of a quartz claim is limited to 100 feet in length along the course of the vein by 300 feet on each side of it, and under this rule no miner or party of miners can hold more than 1,000 feet along the course. A prospecting claim may be double an ordinary claim, but not more than six such claims may be held together as one claim. They must be at least half a mile distant from any previously existing quartz workings, and be fully occupied within seven days from the date of the grant. A prospecting area on a quartz reef may be 300 yards square in extent, and situated at a distance of not less than half a mile from any existing quartz workings, and the same distance from any other prospecting area ; they must be worked continuously by at least two men during the entire period of occupancy ; and the right to occupy only continues in force until gold is struck, when claims must be marked out under the regular provisions of the act.

Other regulations provide for aid towards prospecting being granted by the council of any county and the government, or by a road board where the

Counties act is not in force—the government granting pound for pound up to £500 a year in the case of county councils and to £200 in the case of road boards. Under this arrangement one party of two or three men in each riding of a county may be subsidised at the rate of 15s. per week per man for prospecting new and unprospected country three miles from any main or district road and from any known workings; and in the case of partially worked and prospected country within tolerably easy access of road communication they may be paid at specified rates per foot for sinking, tunnelling and driving. But in both cases the approval of the council is required before operations are commenced, both as regards the men and the locality, and each prospecting party is required to send a report once every month to the council. Similarly the government grants a subsidy of pound for pound to councils or boards for the purpose of rewarding the discovery of mines of gold, silver, tin and diamonds; being a reward of £100 per 100 miners up to £500 for 500 or more men profitably employed at such mines. Government and municipal grants to prospectors and discoverers.

NEW SOUTH WALES.

All grants of land issued under authority of the Crown Lands act of 1884 in New South Wales contain a reservation of minerals in the land; but if any mineral is discovered subsequent to the grant, and the owner desires to mine it, he may do so upon receiving a permit from the government, subject to the payment of a royalty. The regulations require that he shall make a return quarterly to the secretary of mines of the quantity and value of minerals raised, verified by a statutory declaration, and pay a royalty at the following rates, viz., coal 6d. per ton, gold 2s. per oz., and other minerals £5 per centum of their market value at the pit-mouth. Lands in proclaimed gold fields within areas reserved from sale and lands under lease or lawful occupation for mining purposes are exempt from sale under the act; but the Crowns Land act does not in any other respect affect the right of property held in lands under the Mining act. The Mining act has been in operation since 1874, saving in so far as it has been changed in some unimportant particulars by four amending acts. Previously all powers and duties in relation to mining on crown lands were vested in the department of the secretary for lands, but the Mining act authorised the government to establish a department of mines and to appoint a responsible minister with the title of Secretary of Mines who should have the management and control of the department. The act consists of 131 sections, which deal with (1) management and regulation, (2) administration of justice and (3) penalties. Following is a summary of the chief provisions of the act: Minerals reserved by the crown. Mining act of 1874.

1. The governor is authorised to establish in connection with the department a school of mines and a mineralogical museum for the purpose of providing instruction by means of classes, lectures or otherwise in geology, mineralogy and chemistry in their scientific and practical application to mining pursuits, together with offices for the assaying of mineral ores, the school and museum to be under the control and management of the department; or if thought fit they may be established in connection with the university of Sydney, in which case they are to be under the control and management of the senate of the university. School of Mines and Museum.

2. Eight mining districts are established, each of which may be divided by the Governor into divisions, and the governor may appoint a warden for each district to exercise jurisdiction over it, together with registrars, surveyors, engineers and other officers for the efficient performance of the duties of inspection, surveying and Mining districts

registration of claims and mines, and of all other duties in connection with mining and the administration of the act; but no officer so appointed is permitted to hold, directly or indirectly, any share or interest in any claim, lease or mining venture during his term of office.

Miners' rights.

3. The governor may issue a miner's right to any person applying for one for a period not exceeding fifteen years at the rate of 10s. a year for every year for which the right is to be in force, and every holder of a right (or any number of persons collectively each being the holder of a right) is entitled to occupy and mine for gold any crown land covered by his right, to construct water-races and dams for mining purposes on any crown lands and use the water for gold mining and domestic purposes, to erect and remove any building upon and remove any timber, stone or gravel for mining or building purposes from any crown lands not by law exempted from occupation for mining purposes, to make tramways and other roads for the carrying out of all gold mining operations, and to the absolute property in all gold found during the continuance of the right; but no person is entitled to occupy for the purpose of residence more than one-quarter of an acre in extent. The person who takes possession of a claim is required within one month after procuring a right of occupation to register his claim in the office of the registrar of the mining district in which the claim is situated, first producing his right to the registrar, and whoever neglects to register his right is subject to the penalties prescribed for unauthorised mining and his claim may be considered as an abandoned one; and no person is entitled to enter proceedings in any court to recover possession or to restrain the occupation of or encroachment upon a claim unless he is the holder of a miners's right. Business licenses may also be issued under similar conditions.

Registration of claims.

Certain crown lands exempted from miners' occupation.

4. All crown lands dedicated to any public use or which are used as a yard, garden, cultivated field or orchard, or upon which any house or dam may be lawfully standing, or which may be reserved from occupation by the governor, are exempted from occupation under any miner's right or business license; but the governor may upon application grant the privilege to holders of miners' rights to construct drives under lands so exempted providing they can be constructed without injury to the enjoyment of the lands.

Registering a claim for suspension.

5. The registered owner of a claim upon proving to the satisfaction of the warden by evidence on oath in open court (1) that the claim is unworkable from any cause, (2) that he requires to be absent from the locality for sufficient cause or is unable by reason of sickness to work the claim, or (3) that the supply of water is insufficient to allow the working of the claim to be profitably carried on, may register the claim for suspension of work for any period not exceeding six months.

Gold-miners' lease.

6. A lease for gold-mining purposes may be granted to any holder of a miner's right for a term not exceeding fifteen years, but no lease may embrace more than 25 acres, the length of which shall not exceed twice the breadth; except in case of quartz-veins or lodes, when the lands leased shall not exceed six hundred yards along the lode by two hundred yards across it. The rent of a lease is fixed at 20s. per acre yearly, payable in advance.

Proving an application for miner's lease

7. The application for a lease is held by the warden for fourteen days, when if no objection has been lodged against its issue it is forwarded to the secretary of mines to be dealt with under the provisions of the act. But should any person object to the issue of the lease to the applicant he must within the prescribed time serve a written notice of every objection intended to be taken and deposit a sum for the purpose of defraying all expenses of a hearing, which shall be in the nature of an enquiry by the warden into the truth of the particulars stated by the applicant and the objector; and the matter is then referred for the decision of the governor. In the case of two or more applications being lodged at the same time, the claim is determined by lot.

Possession and survey of a leased location.

8. The person acquiring a lease and making the first payment therefor may take possession of the land so soon as he has marked out the boundaries in the manner prescribed by the regulations. In case the land is not surveyed at the time of lodging the application for a lease by some person authorised by the secretary of mines the party may deliver a written application to the warden for a survey of the land, and if no survey is made at the end of three months the lease holder may cause a survey to be made by any licensed surveyor.

Leases to be registered.

9. Every gold-mining lease is required to be registered as prescribed by the regulations, and the land may also be registered for suspension of work the same as in the case of a miner's right for a period not exceeding six months.

10. Leases for the mining of any metal or mineral other than gold may be granted subject to the following conditions: (1) The area not to exceed 640 acres

for coal-mining lots nor 80 acres for other mineral lots. (2) Leases to be for a period not exceeding twenty years, but renewable. (3) Applications to be made, as prescribed by the regulations, to the warden if the land be within a mining district, or if otherwise to the land agent of the district or other officer authorised by the regulations, and to set forth a clear description of the lots proposed to be leased and of the boundary marks or natural features by which they may be identified, when the applicants may forthwith take possession; but the minister of lands reserves the right to determine the boundaries of all lots and all other provisions he may deem necessary for the public interests. (4) Rent is fixed at 5s. per acre, payable annually in advance. (5) Lessees are required to expend at the rate of £5 sterling per acre on their lots within the first three years of the lease, and they may determine their leases by giving to the minister three months notice of their desire to do so. (6) Lessees on application to the secretary of mines in the nineteenth year of their leases may obtain a renewal for a further period of twenty years, subject to a fine of not less than £2 10s. per acre; and full information of the working and returns of the mine are required to be furnished to the secretary of mines by lessees on pain of forfeiting their claim to renewal. (7) If any lease be forfeited and not renewed the lessee has the right within six months of the termination of his lease to remove or otherwise dispose of all machinery and improvements and the minerals brought to the surface during the term of his lease. (8) Upon the breach of any condition of a lease by the lessee the governor may direct the cancellation of the lease.

Other mineral leases and conditions under which they are granted.

11. In the event of a dispute arising as to the right to any lease the secretary of mines may appoint a competent officer to make inquiry into the dispute, and should it appear that the property is liable to be prejudiced by the working of the minerals therein pending the inquiry the secretary may serve upon either party his injunction for the suspension of all mining operations until the right to a lease has been duly determined in favor of either party.

Settlement of disputed titles.

12. Where some other mineral or metal is found in the land other than that for the mining of which the lease was obtained and there is a desire to mine it, the holder is required to give notice to the secretary of mines and obtain authority to work the same; otherwise his lease is liable to forfeiture and cancellation for a breach of the condition.

Lessee to give intention to work more than one mineral.

13. The governor is authorised to make regulations prescribing the terms and conditions on which rights and licenses may be granted, for enforcing penalties, etc. He is also empowered to call together a mining board consisting of two members appointed by the governor and nine members elected by the people to make regulations for the working of gold mines, subject to the governor's approval, and all regulations so approved have the force of law.

Regulations.

Mining board.

The remaining clauses of the act provide for the administration of justice in mining districts by the establishment of wardens' courts, and for penalties and forfeitures for specific breaches of the act and of the regulations under it. Various regulations have been adopted dealing with the mining board, mineral leases of crown lands, water courses, mineral licenses, occupation of reserved lands and the construction of drives under exempted lands, mining under public roads, gold mining leases, practice and procedure in wardens' courts and the inspection of mines other than coal and shale mines, all of which are published in the seventh edition of the Mining act, 1888. The regulations of the mining board were published in 1875; they deal exclusively with mining for gold, and with the duties of mining registrars and surveyors.

Other clauses of the act.

Regulations.

VICTORIA.

The mining laws of the colony of Victoria are embraced in what is known as the Mining statute of 1865, being an act to provide for the management of mining interests and the administration of justice in relation to the same. It consists of 246 sections and is divided into three parts, viz.: (1) mining management, (2) administration of justice, including administra-

Mining statute 1865.

tion under courts of mines and wardens, and (3) penalties. Following is a summary of the provisions of the part relating to mining management:

Miners' rights.

1. The governor in council may issue to any person applying therefor a miner's right for any number of years not exceeding fifteen, upon payment of a sum at the rate of 5s. for every year in which it is to be in force, or may issue a consolidated miners' right on the application of a manager or trustee of any company of persons who have agreed to work in partnership any registered claim or claims upon payment of 5s. per year for each person in the company. The holder of a right is entitled to take possession of a parcel of land for gold mining purposes of such extent and with such boundaries as bye-laws made under the statute may define, and may also cut and use the timber upon it and may occupy a plot not more than a quarter of an acre in extent for the purpose of a residence. A claim or share in a claim may be registered upon the production of the miner's right, when it may be assigned, encumbered or transferred subject to any trusts or provisions agreed upon between the parties.

Business licenses.

2. A business license may be issued to any person applying for it upon payment of £2 10s. for six months or £5 for twelve months, under which the holder is entitled to occupy on any gold field for the purpose of residence and carrying on his business one quarter of an acre of land, but his property in it is deemed a chattel interest. He may transfer the license to any other person for the unexpired period upon expressing his desire so to do before a warden or a justice, and upon payment of a fee of 10s. another business license is granted to the purchaser.

Renewals.

Exempted lands.

3. A miner's right may be renewed upon payment of a fee of 5s. and a business license upon payment of 25 per cent. of the original fee, and the right of renewal holds for one month after the date of expiration. The right of occupying exempted lands for occupation under miner's right or business license is the same as under the New South Wales act.

Right of property in buildings.

4. When land held for business or residence is put up for sale the value of buildings thereon is fixed by arbitration, and the value so ascertained is added to the upset price of the land, when if the holder of the license or right is the highest bidder the value of the buildings is deducted from the amount of his bid, but if any other person become the purchaser then the holder is entitled to receive out of the purchase money the value of his buildings as fixed by the arbitrators.

Gold mining and mineral leases.

Prospector's lease.

5. The governor may grant to any person or body corporate a lease of any crown land not otherwise demised under miner's right or business license for the purpose of mining for gold or other mineral, to be known respectively as a gold mining lease or mineral lease; provided, however, that land held for the purpose of a residence under miner's right or business license may be leased upon payment to the holder of compensation for buildings or other improvements upon the property. In the case of a gold mining lease the term for which it may be granted cannot exceed fifteen years, subject to a yearly rent of £1 per acre; and in the case of a mineral lease the area cannot exceed 640 acres nor the period thirty years. Any holder of a miner's right who desires to prospect for gold in any place where sinking through basalt is necessary, and to which no part of any gold workings is nearer than five miles, may mark off an area of one square mile for prospecting work, and in the event of his discovering gold in quantities which the governor in council may consider remunerative the person is entitled to a lease of any selected part of the area not exceeding one hundred acres in one lot (whether occupied by a miner's right or business license or not) at a nominal rent and for such term as the governor in council may determine. Any such license may be surrendered or renewed, with the consent of the governor in council; but in the case of a new lease it shall be at the rent which is then chargeable by law, and subject to the payment of a fine of £10. Leases may also be granted for any water reservoir constructed at the public expense.

License to search for minerals and metals other than gold, and to construct races and reservoirs.

6. Any person may procure a license to enter upon crown land not demised, or not occupied by the holder of a miner's right or business license, to search for any metal or mineral, other than gold, subject to a fee, rent or royalty fixed by the governor in council. Licenses may also be granted to construct races, drains, dams and reservoirs for a term not exceeding fifteen years.

Various provisions respecting leases.

7. A warden may hear objections to the granting of a lease and take evidence relating to an application therefor, and although an applicant may comply with the regulations the granting of a lease or license is not obligatory; but no lease or license can be granted until after the lapse of one month after notice of the intention

to grant it has been published in the government Gazette and in some newspaper circulating in the district within which the land is situate. In case any lease becomes liable to be forfeited by any breach of condition or otherwise, the land may recovered by the crown as may be provided by the conditions or by suit in the court of mines.

8. The governor in council is authorised to make regulations under the act prescribing the term for which any license or lease is to be held, the amount of rent, royalty or fee to be paid, the quantity and shape of the land to be demised, the manner in which the land is to be marked out, the mode and time of determining upon applications, the manner of dealing with cases when two or more applications are made for the same land, how leases are to be registered, the conditions upon which leases are to be issued and the privileges to be enjoyed under them, etc.; but no such regulation can have force or efficacy until twenty-one days after it has been published in the government Gazette, and every regulation or change thereof is required to be laid before parliament.

Regulations of the governor in council.

9. The governor in council may erect any portion of the colony into mining districts and divide each of such districts into any number of divisions, fix and alter the boundaries of districts and divisions from time to time, and determine the number of members of the mining board of each district which may be elected for every division; but the number of districts may not exceed seven except upon an address to the governor by the legislature praying for a greater number. The governor in council may also appoint as many officers, clerks and assistants for each district, division or place as may seem right for the making of inspection and surveys and registration of claims and mines, and such other duties as the governor in council may think fit.

Mining districts and officers.

10. Each district is empowered to elect a mining board consisting of ten members, a certain number to be chosen by ballot for each division of the district as determined by the governor in council, four of whom retire annually by rotation. None but holders of miners' rights or business licenses resident in a division, twenty-one years of age and subjects of the queen, are eligible for election to the board, and the same qualification is required of voters, each of whom has as many votes as there are members to be returned for his division. The places of meeting for the board are fixed by the governor in council, and a sum of £500 is paid annually out of the consolidated revenue of the colony for apportionment amongst the members of each board according to some scale to be adopted by the board and approved by the treasurer of the colony. The board has power to make bye-laws for the regulation of mining in its district or part thereof within limits prescribed by the act, which if concurred in by the law officers of the crown and published for twenty-one days in the government Gazette acquire the force of law; but any bye-law is revokable by the governor in council for cause.

Mining boards.

The Land act of 1884 provides that no auriferous lands shall be alienated in fee simple, and that all lands alienated under the act are liable to be resumed for mining purposes by the governor in council on paying full compensation to the licensee, lessee or purchaser in fee simple for land and improvements, but not including auriferous value. The governor may also grant leases of any crown land not exceeding three acres for a term not exceeding twenty-one years, at a yearly rent of not less than £5, for the working of mineral springs and the manufacture of salt. The act furthermore provides that in every crown grant of lands alienated in fee simple, as well as in every license or lease demised with the right of acquiring the fee simple, there shall be inserted a condition that the land is granted subject to the right of any person being the holder of a miner's right or of a mining lease to enter upon it and mine for gold and silver under the same conditions and provisions as those to which such person may mine upon crown lands, provided that payment be made to the owner for surface damage; and any warden may hear and determine any claim for surface damage, subject to appeal to the court of mines.

Lands alienated may be resumed for mining purposes.

Leases for working mineral springs and manufacturing salt.

Miners' rights on alienated lands.

SOUTH AUSTRALIA.

Mining laws.

The mining laws of South Australia are embraced in three statutes, enacted in the session of 1888, viz.: (1) the Crown Lands act, (2) the Northern Territory mineral act, and (3) the Mining on Private Property act.

Crown Lands act

Under the Crown Lands act lands granted except in pursuance of any agreement for sale made before a certain date in 1886 are not to be construed to convey property in any gold, silver, copper, tin or other metals, coal, oil, gems or precious stones; and the commissioner or any person authorised by him may enter upon lands so granted to search for minerals or work mines, provided reasonable compensation for damage is paid to the owners exclusive of the value of metals or minerals found on the property. Following is a summary of the provisions of the act which relate to leases and licenses for mining purposes:

Lease of mineral lands for mining purposes.

1. Leases of mineral lands may be granted for mining purposes in blocks not exceeding 80 acres to any person or company who first applies for it; such leases to be for a term not exceeding ninety-nine years, and to entitle the lessee to mine all metals and minerals on the land except gold. In case improvements have been made on the land the person applying for a lease is required to pay into the treasury a sum to be fixed by the commissioner for their value.

Rent.

2. The annual rent under a mineral lease is 1s. per acre, besides 6d. in the pound sterling on the net profits of mining works, payable half-yearly; and for the purpose of ascertaining the amount of rent so to be paid the lessee or manager of the leased land is required to make returns to the commissioner certifying the amount of gross and net profit from the working of the leased land for the preceding six months, subject to a penalty of not less than £50 nor more than £500 for a wilfully false return.

Conditions of lease.

3. Every mineral lease contains covenants by the lessee, (1) that he will pay the rent when it becomes due, (2) that he will not without permission from the commissioner use the land for any other purpose than mining and smelting minerals, (3) that he will expend every two years of the term a sum equal to at least £6 for each acre of land comprised in the lease in working the mines, or that during nine months of each year he will keep one man for every twenty acres employed in mining or searching for minerals, (4) that he will forward the returns required by the act, and (5) that he will permit the occupier of any adjoining pastoral lands to have free access to and use of any water on the leased land not provided by artificial means. Every lease also contains a proviso that it is liable to forfeiture upon breach of any of the covenants; but the lessee may surrender his lease on giving notice to the commisioner.

License to search.

4. The commissioner may grant licenses to search for metals and minerals except gold on any specific mineral lands not exceeding 80 acres in extent, on payment of a fee of 20s.; such license to be in force for one year, and to authorise the licensee during its currency to search and mine the land and take any minerals and metals, except gold, not exceeding one ton (or 20 tons with the consent of the commissioner), for sample and analysis only. But no person can hold more than 80 acres of mineral lands at the same time for this purpose, and he must employ at least one man nine months of the term in searching for minerals, or in mining work. Licenses less stringent in their provisions may also be granted to search on any mineral lands.

Right of renewal.

5. The holder of a mineral lease is entitled to renewal upon its termination, on payment of a fine or premium to be fixed by valuation; and in case the lessee does not avail himself of the right of renewal, or on the forfeiture of the lease, it must be offered for sale by auction.

Gold mining leases.

6. No mineral license includes or applies to any lands held or occupied for gold mining purposes, but the holder of a gold mining lease is entitled to a preferential right to a mineral lease of the land comprised in his gold mining lease. Any mining company may hold any number being not more than twelve gold mining leases or mineral licenses.

7. The lessees of contiguous lands held under gold mining leases may readjust or alter the boundaries of the lands by taking out new leases for the unexpired term, but no new lease can be granted for a greater area than twenty acres.

The provisions of the Northern Territory mineral act are in the main the same as those of the Crown Lands act, saving that specific licenses to search for minerals may have a maximum area of 640 acres, and that mineral leases cannot cover more than 320 acres in contiguous blocks nor more than 640 acres in all at one and the same time.

Northern Territory act.

Under the Mining on Private Property act the governor may provisionally resume the ownership of any private land for mining purposes for a period of six months upon a written application being made to the commissioner desiring the land to be so resumed, and the certificate of an inspector that it should be resumed for the purpose of mining; and upon the land being proved satisfactory for mining purposes the resumption may be made absolute at the end of the period of six months upon payment of the purchase money. The land may then be put under license or lease in the ordinary way. But without the resuming of ownership of the land by the government any person may apply to the owner of any private land for a mining lease of any portion of the land, not exceeding twenty acres, for gold mining. In the event of the owner refusing to grant a lease it becomes the duty of the inspector to examine the land, and if he should report that payable metal exists therein, and that it should be resumed for mining purposes, the owner must either work it himself or grant a mining lease for it upon regular application being made therefor; and in case he refuses the lease may be executed by one of the judiciary officers. The lease is required to be granted for a term of twenty-eight years, subject to a royalty of $2\frac{1}{2}$ per cent. on the gross money value of the metal raised from the land during the currency of the lease, and such rent for the surface of the land as may be assessed by the nearest local court having jurisdiction in such matters; but if the court is of opinion that any special injury is likely to arise to the land under the lease, it may order that the land be purchased. In case the metal on leased private land has been reserved to the government no royalty is payable to the owner of the land, but the whole must be paid to the commissioner.

Mining under the Private Property act.

Government may resume ownership.

Claim to lease private land.

Royalty.

In Queensland, Western Australia and Tasmania the mining laws and regulations are in respect of miners' rights, business licenses, mining leases, the administration of justice and inspection essentially like the laws and regulations of Victoria and New South Wales, differing only in details. In Queensland the discoverer of a new gold field distant more than twenty miles from any place where payable gold has been previously obtained, on which not less than 200 miners are employed four months after discovery, the government may pay a reward not exceeding £500, and for one on which not less than 500 miners are employed six months after discovery a reward not exceeding £1,000 may be paid. In Western Australia a system of reward claims has been adopted for the discovery of gold, graded according to distance from the nearest occupied gold workings, ranging from two claims of one man's ground* if distant over four hundred yards to ten claims if over three miles and to twenty claims if beyond the limits of a gold field. For discoveries of gold in payable quantities in new fields of certain specified

Mining laws and regulations of other Australasian colonies.

Rewards for discovery of ne fields.

*An ordinary alluvial claim for one man is 50 feet square, and a wet alluvial claim is 50 by 100 feet.

divisions of the colony the government may pay a reward of not less than £500 and not more than £1,000, but not more than one such reward may be paid in respect of each division. In Tasmania the government may grant to any person who discovers any mineral a lease at a pepper-corn rent of any area which may be prescribed.

European mining laws.

For a knowledge of the mining laws which prevail in the principal countries of Europe the writer is indebted to reports made to the British government by her majesty's representatives abroad, "as to the laws in various countries regulating the ownership in minerals and mining rents and royalties," presented to parliament in 1887. Only a brief summary of the reports is given.

FRANCE.

Mines are the property of the nation.

The payment of royalties in France was abolished in 1789 and all mines were declared to be the property of the nation, reserving to the owner of any land the right to mine upon it provided he went no further down than 100 feet. This law was repealed in 1810, but the new law re-enacted all the old provisions saving the right of the owner to open shallow mines without leave; and in its chief features the act of 1810 is the present law of the country.

Right of private land owners.

No person can try or prospect for minerals, whether with or without the assent of the owner of the land, unless he has previously arranged to pay the owner an indemnity; and if the works are so far temporary that the ground may be cultivated as before at the end of one year, the damage cannot be calculated at more than twice the net return of the land occupied; but if the works should deprive the owner of his ground for more than a year, or unfit it permanently for cultivation, the explorer must buy the lot for a sum not to exceed double its value before occupation.

The government concession.

No mine, however, can be worked without a concession from the council of state, the obtaining of which creates a new property even to the owner of the soil, independent of and separate from that of the surface and transmissible like any other. As soon as the concession is obtained—and it may be granted to foreigners as well as to citizens—the concessionaire is bound to pay yearly rents to the owner of the surface on the whole extent of the concession, and also for the surface area occupied by his machinery and plant; also a yearly rent to the state, besides 5 per cent. of the net produce of the mine and a small sum additional to form a relief fund for accidents.

Rents.

GERMANY.

Law of 1865.

The mining laws in Germany are not uniform throughout the empire, but the Prussian general law of 1865 has been extended to most of the other states. The minerals are not at the disposition of the owner of the soil, but it is a moot question whether they form before the right to work them is obtained an integral and judicially indivisible part of the ground and soil, or "things without an owner." This, however, is of no real consequence as under the general mining law all persons (including the owner of the land) who dig for minerals without a license obtained from the state mining authorities are punishable by fine or imprisonment. A claim to license is recognised as belonging to the person who has discovered the mineral in its natural state and makes an application for the concession. The license is granted for limited and bounded areas, which are marked out by straight lines on the

Licenses.

Rights of the surface owner.

surface—the boundaries underground being lines vertical to the horizon. This license or lease conveys absolute right to work for the mineral mentioned therein within the prescribed area; and once it has been given it can only be cancelled without the licensee's consent when the higher mining authorities have decided that this step is necessary on public grounds. The law of 1865 does not recognise that the owner of the soil has any claim to a royalty, rent or similar advantage of the nature of compensation for the raising of minerals which may happen to underlie his property; but the owner of the mine is obliged to give full compensation for such surface portions of the property as he may require, as well as for any damage he may cause to the property or its appurtenances by his mining operations. An essential feature of the law is that which provides for the payment of a tax or royalty to the state on all mineral properties except iron mines, rock salt mines and brine works,—the form of levy being (1) a tax on the gross produce, as in Prussia, (2) a tax on allotments, as in Hesse, (3) a combination of both, as in Alsace-Loraine, or (4) a general tax on industry, as in Wurtemberg. The royalty in Prussia is two per cent. to the government; and the mine owners are required in addition to pay certain charges to the miners' benefit fund, to ensure assistance to the miners in case of illness or accident, and to provide for their widows and children.

Tax or royalty payable to the state.

Miners' aid fund.

AUSTRIA-HUNGARY.

In Austria the state claims sovereign rights over all minerals. A permit to search is granted on application, but it is limited to a certain district, the area of which must be accurately stated. Having obtained a permit, the next step is to apply to the authorities for one or more free diggings in the district, each of which is to measure not more than 424 metres (1,391 feet) in diameter. An arrangement must then be concluded with the owner of the land where the opening is proposed to be made; and if a purchase of the land is intended, and the parties cannot agree on the price to be paid, the value is fixed by sworn experts appointed by the mining authorities, whose valuation must be accepted by the proprietor. He may also be forced to cede his property temporarily at an annual rent, to be fixed by sworn experts, in which case the land reverts to his free use after the working of the mines has ceased, but this plan is of rare occurrence. No royalties are paid to the state, but heavy rates of taxes are imposed for both state and municipal purposes.

Permits.

Rights of owners of land.

State and municipal taxes.

ITALY.

In Italy the old laws which obtained in the independent states before the unification of the kingdom still continue; hence the most contradictory systems are found side by side. In all upper and central Italy, with the exception of the Tuscan provinces and in the island of Sardinia, concessions are granted by the government in favor of the discoverer of a mine, or of any other person who may furnish a sufficient guarantee of his intention to under take the working of it. In the provinces which formed part of the late kingdom of the two Sicilies, when the working of a mine is not undertaken by the owner of the soil, concessions are made by the government in favor of any duly qualified applicant who possesses the means of undertaking and carrying on the work; exception being made in the case of sulphur mines, which can

No uniform laws for the kingdom.

only be worked by the owner of the soil. But sulphur works in Sicily are still subject to the supremè regalian rights of the state, and the owner of the soil may not open or work them without a special license, and upon payment once for all in recognition of the sovereign rights of a sum of 127½ francs. In the Tuscan provinces mines are the absolute property of the owners of the soil, saving iron mines of the island of Elba and the territory of Piombino; these belong to the state domain, and may be conceded to any person upon any terms. Various attempts have been made in the Italian parliament to introduce a uniform law for the whole kingdom, but so far without success. All owner of mines, however, are required to pay an income tax of 13.2 per cent. on the produce of their mines, independently of any tax imposed by the various mining laws.

Income tax.

BELGIUM.

Everything above and below the soil was recognised by the old law of Belgium as belonging to the owner, but this was completely changed by the imposition of the French law, passed by the French imperial government in 1810. This continued to be the law of Belgium until 1837, when considerable changes were made looking to fairer treatment of the land owners. By the law of 1837 the land owner, like the state, receives a double royalty, the one fixed by the act of concession, but in no case to be less than 25 centimes per annum for each hectare (about 5 cents for each 2½ acres); the other proportional, from 1 to 3 per cent. on the net product of the mine. In both cases the rates are determined by the board which grants the concession, and the amount is divided among all holders of land included in the concession in proportion to the extent of their holdings. The law also provides that the owner of a sufficient extent of land, who possesses the necessary capital, is entitled to the concession.

Law of 1837.

Double royalties.

PORTUGAL.

The right of private ownership in minerals is recognised by the law of Portugal, but the control over and management of mines is entrusted to a committee of public works, which is subordinate to one of the state departments. The government may through this committee grant permission to search for minerals in land which is national property or the property of municipalities, and may also authorise search to be made on private lands without the consent of the owner of the soil, but subject to an engagement on the part of the explorer to indemnify the owner for any damage he may cause. Previous to commencing operations on private land the lessee must either compensate the owner by paying the value of the land set apart and one-fifth part of the value in addition, or he must give security to the full amount of any injury that may result. In all cases where shafts have to be sunk or galleries constructed the previous consent of the government is necessary, and this requirement applies to the owner as well as the lessee of a mining property; any person who does so work a mine is liable to have the fruits of his labor appropriated by some other person registering himself as discoverer and obtaining a concession. The scale of royalties as fixed by the decree of 1862 requires the lessee to pay to the state a sum not exceeding 5 per cent. of the net production and a sum not exceeding 2½ per cent. to the owner of the soil,

Private ownership recognised.

Right to explore.

Government consent is necessary to work a mine.

Royalties.

the annual rent being always one-half of the proportional royalty exacted by the government; but in the event of the government converting the proportional royalty into a fixed amount, or suspending temporarily the payment of a royalty, the parties may either agree upon the sum to be paid to the owner or the government will fix the percentage within the legal limits.

SPAIN.

Any person or company may own mining property in Spain, with the consent of the state and subject to certain conditions. The law deals with minerals of three classes, viz.: (1) all materials used for building purposes and found in quarries, (2) surface metalliferous deposits, and (3) metalliferous mines, coal, oils, sulphur, precious stones and kindred substances. Mineral substances of the first class found on private property appertain to the owner of the land, but if they can be utilised in any industry the owner is bound to quarry them within a specific period, or on the application of any other person the deposits may be expropriated. When found on government or common land any person may utilise them, with the consent of the government. Deposits carrying gold and tin, or other river deposits such as yellow and red ochre, may be utilised without previous permission. Under certain conditions any person may examine the surface of the land for minerals, and if the owner refuses consent the civil governor of the province may grant permission upon application being made to him. In order to obtain ownership of a mine a petition is addressed to the civil governor, who instructs a government engineer to examine and report upon the property, and if signs of minerals are found the concession is at once granted, and the property must be marked out within four months after the concession. A mine is reckoned to be a rectangle measuring 200 by 300 metres, and of indefinite length; but in the case of iron, coal, bitumen and sulphate of soda the limit is 300 by 500 metres. Mines of 200 by 300 metres pay an annual royalty to the government of £3, mines of 300 by 500 metres pay £2, and scoriæ mines and surface deposits pay £4 for every 40,000 square metres.

Classes of minerals.

License to search.

Area of mines.

Royalties.

SWEDEN.

The rights of property in mines in Sweden are regulated by the mining law of 1884. The owner of the land is not entitled to the minerals found in it, except in the case of minerals in the lakes and swamps, and no mines can be worked without a license. Whoever wishes to work a mineral vein, whether on his own ground or that of any other person, must make a written application to the mining inspector of the district for a mining license, and and this license when granted refers to a certain area with perpendicular boundaries. As long as work of exploration is continued the holder of the license must compensate the owner of the ground by paying him in advance an annual rent for the area occupied, and under pain of losing his claim he must commence working within at least eight months from the date of the license, unless a hindrance occurs over which he can have no control. The owner of the ground, however, is entitled to share with the holder of the license in the mining and the profit derived from it to the extent of one-half, and it is optional with him to use either his whole share or part of it. In the case of a crown tenant or occupier who holds by perpetual lease,

Mining law of 1884.

Mining license.

Conditions.

the same right is enjoyed as is secured to an owner; but any one entitled to a ground-owner's share, and neglecting to make application for the use of it, forfeits the right to such share. The allotment staked out under a license may not, excepting under special circumstances, exceed 200 metres square, and the fee to be paid to the owner must be decided on the staking out of the allotment, either by agreement between the parties or by official appraisement. Mining work within any licensed area must be carried on upon such a scale as to equal the cost of blasting 10 cubic metres in the mine every year, but the owner is entitled to perform in one year the work he is bound to perform for several years, not exceeding four. Instead of this obligation the owner of the mine, if he prefers to do so, may pay an annual fee for each allotment of 50 kronor (about $13.50), half of which goes to the crown and half to the owner of the ground; this right, however, is not admitted unless obligatory work in the mine has been performed for at least three years. In the case of the owner of the mine being also the owner of the ground, he is bound to pay only the portion of the fee which goes to the crown. In case of failure to perform the obligatory work, or to pay the annual fee where the payment of such fee is admitted, the mine and the privilege based on the license become forfeited at the end of the year, provided that a complaint be made to that effect within two years from expiration of the working year during which the neglect took place. In case of forfeiture, or the loss of a mining claimant's right in any other way, the whole real property in the mine reverts to the owner of the ground without any compensation, saving that any ore that may have been raised is allowed to remain on the ground on account of its owner for two years free of expense; and any machinery remaining in the mine, constructed for its support and durability, becomes the property of whoever afterwards acquires a legal title to the working of the mine. No foreigner is allowed to work a licensed allotment, or carry on mining in the kingdom, except by making special application and obtaining permission from the king. Formerly a payment of 10 per cent. for certain privileges granted by the state was exacted, but by a series of agreements between the state and the mine-owners this tax for the privilege of working mines has heen abolished, excepting in two districts. With this exception the mining industry is now only subject to the ordinary income tax, and the payment of a fee of 10 kronor (about $2.70) for an act of concession.

Mining work regulated.

Forfeiture.

ncome tax.

NORWAY.

By the Norwegian mining law of 1842 the right of raising lake-ore and limonite is reserved to the owner of the ground, and by the law of 1869 the same right applies to the obtaining of alluvial gold; as regards all other ores and metals, the owner of the ground has no special right, except the privilege of participating in the working of the veins. Any one who discovers a vein may notify the constable of the parish or magistrate of the town, which notice when communicated to the owner of the ground and published at the church, or in any other customary way, gives the person who presents it a preferential right for a period of eighteen months to obtain a certificate of permission to work the mine. Applications for such permission must be made to the super-

Rights of the land-owner.

Right of a discoverer.

intendent of mines, and be accompanied by a specimen of the ore; and the person who obtains permission to work a metallic vein and duly publishes his certificate may claim an allotment of ground on which he may be exclusively entitled to such working of the mine as is stated in his certificate. But to prevent forfeiture of the privilege so obtained the mine must be continually worked, otherwise a respite must be applied for within a month from the time the work has ceased. The right of working a mine is limited by the right of the ground-owner to participtate in the work to the extent of a tenth part of the claim, and in case the ground-owner does not choose to avail himself of this right he is at liberty to transfer it to others. No tax is paid for the working of a mine, either to the government or any private individual, but the officer who draws up the certificate of permission and grants respites is entitled to certain fees. It is a disputed question whether foreigners may search for ore at all, or acquire the privilege of working a mine.

Ground-owner's interest.

SUGGESTED CHANGES IN THE MINING LAW.

III. In considering any proposed change of the mining law of Ontario regard must be had in particular (1) to the system of land tenure which obtains in the country, (2) to the effect of laws and regulations already tried, and (3) to the provisions of the mining laws of the United States.

It may be that tenure in fee simple is not the best. The lease system has strong advocates among the friends of so-called land-law reform, and it is upon trial on a large scale in New Zealand and in the Australian colonies. But in Ontario, where the great majority of occupiers are owners, it would be difficult to persuade people that any other system is better. The merits of the lease system were carefully weighed before the adoption of the first mining regulations, and in all the changes made since that time the only approach to the adoption of that system is found in the licensing provisions of the law relating to mining claims in mining divisions, in which respect it has failed altogether. As long as the law permits a miner or other person to become the owner of 80 or more acres of mineral land, it is not likely that he will be content to take up and work a claim of 200 feet square. Still less is the American or other foreign capitalist likely to invest money in a leasehold in Ontario, when in a neighboring state he may procure a mining location under an absolute title. But while it does not appear that the land tenure of Ontario ought to be changed in the mineral-bearing regions, or even that there is a desire for such change, there are several particulars in which, as exemplified by the experiences of our own and other countries, changes in the law might conduce to larger and more continuous development of our mineral wealth.

Tenure of the land.

We have in the northern and north-western regions of the province an area of 100,000 square miles, mostly wilderness. A large portion of this area lies in the Huronian formation, which is mineral-bearing, and from the discoveries already made there is reason to hope that it is rich in at least some of the precious and economic metals. But even the best known sections of it have been imperfectly explored. It is, indeed, a difficult country to explore, being for the most part a forest land, remote from settlement, dotted with

Claims of the explorer to consideration.

numberless lakes and intersected by deep-flowing streams and rivers. The prospector who ventures out into it has constant hardships to face. Supplies must be carried on his back, he cannot travel far without being obliged to return and lay in a fresh store, and unless provided with a canoe his course is often impeded by the lakes and rivers. The timber, undergrowth, leaves and moss often hide the mineral-bearing veins from his sight, so that for the most part his way lies along the banks of tortuous streams or the rugged escarpments of the mountain ranges. And when it happens that his toilsome wanderings are rewarded with the discovery of a mineral vein, he may be obliged to spend a season in testing its value—packing in from time to time necessary supplies of food, mining tools, explosives, etc., and packing out the specimens for assay or analysis. Besides, the mosquitoes and black flies make life in the woods almost unendurable until half of the short season for exploration is over. Under these circumstances the explorer has special claims for consideration at the hands of the government. Without his offices long years may elapse before the mineral riches of the country are made known, and even with the most favorable conditions much skill and experience are required to make the search thorough. Whatever, therefore, can make easier the task of the explorer, or encourage his undertakings in old or new fields, ought not within fair and reasonable limits to be denied to him. It may not be advisable to subsidise exploration in new fields and offer rewards for the discovery of ores or minerals, as is the practice of New Zealand. Such a policy is likely to lead to abuses, even in the case of men regularly employed by the government as explorers or prospectors. But the explorer ought to experience no difficulty in procuring information as to locations already claimed or patented, and no delay in filing a claim when he has made a discovery. In almost all mining countries he deals directly with local agencies or offices, where records are kept of every transaction in mining lands and where claims are entered as soon as they are made. The work of the department is limited to issuing patents when the conditions of purchase are complied with, and deciding important matters of dispute when these arise The explorer is not obliged to waste his own or the department's time in eliciting information of the most ordinary kind in his business affairs. At the local office he learns what the terms and regulations of the department are, he ascertains what portions of the district are available for exploration, he procures official maps of the district, and if so fortunate as to make a discovery he files and proves his claim to a location in accordance with the regulations. In giving effect to this plan in Ontario it would only be necessary to authorise the local officers and agents appointed to carry out the Public Lands act to carry out in like way the General Mining act. This change, it is thought, would operate in the interest of the explorer in almost all matters of administration, and would also tend to put a more effectual stop than is now possible on the practice of "jumping" claims. The best protection to the poor man is possible under local administration of the law, with right of appeal in all cases to the department.

Local agencies.

The present law permits any person, alien or citizen, to explore for minerals on any public lands not already marked or staked out and occupied,

and in this respect it is decidedly more liberal than the mining law of the United States. It also provides that such lands may be sold as mining lands when they are "supposed" to contain minerals. In many other countries the law makes discovery a pre-requisite to the filing of a claim—the effect of which is to ascertain with some degree of exactness the extent of the mineral wealth of the country, and to put a check on the purchase of mining land for speculative objects. The evidence taken by the Commission proves that in some districts large areas have been taken up in this way, on the strength of a reported local discovery, without personal examination of the land, without seeing it, and generally without the expenditure of a dollar for an explorer's report upon it. Were the law to require that no application could be entertained until after the discovery of a mineral vein or deposit within the limits of the location claimed, it would doubtless lessen this evil very materially, if it would not make an end of it altogether.

Making discovery a pre-requisite to the filing of a claim

The statistics of the sale of mining lands during the last forty-four years do not give reason to believe that purchase by speculators has been carried on to the extent many persons allege. Neither does the taking up of many locations or large areas by one person or company appear to be a common practice. The most extensive purchases were made in the early days of mining excitement in the country, under the first regulations governing the sale of mining lands; and although frequent efforts have been made to limit the sales to individuals, they have been fruitless of results. The regulations of 1853 provided that in respect of certain minerals an individual might take possession of a tract not exceeding 400 acres, and those regulations were continued with various changes down to 1869. When the mining bill of that year was under consideration the commissioner of crown lands (Hon. Stephen Richards) was asked if he had any plan for preventing capitalists from taking up large quantities of territory. Mr. Richards replied that he had not, and is reported as saying:

Extent and number of locations held as individual claims.

> A former government introduced a policy under which no one individual could take up more than one lot of 400 acres. This was evaded by an individual taking up other lots in the name of his friends. Not long since a party called at the crown lands department who, I have ascertained, has thus acquired a title to eight lots.

A leading member on the opposite side agreed with the commissioner that frauds of this kind could not be prevented by statutory enactment, and that it was idle to cumber the statute book with provisions which were sure to be evaded. Still it may be urged that a statutory provision to limit the number and extent of locations for which one person may take out a patent would operate to prevent speculation in mining lands, especially if the grant was made subject to working conditions. Such minerals as copper and iron require locations of larger area than gold and silver, especially where it is proposed to establish smelting, treating or reduction works in connection with the mines. It would be necessary, therefore, to adopt more than one limit for the various ores, if it was thought advisable to fix a maximum area by statute. But a matter of perhaps equal importance is to determine how small an area of mining land one person may acquire by purchase from the crown. The present law provides that a location shall be at least 40 chains in length

Minimum area of a location.

by 20 chains in width, containing 80 acres. It has already been stated that the measure, as originally presented to the legislature, fixed the extent of a location at 320 acres, but that the views of members were met by placing the minimum at 80 acres. Two or three members urged that miners should be allowed to take 40 acres, and speaking to this proposal Mr. Blake said :

> I am told that a block of 400 acres comprises the richest and almost only productive territory in Nevada, which produces from sixteen to twenty millions of dollars a year. A very considerable number of companies are working on it. One company has taken out fourteen millions of specie in four years from a ridiculously small amount of space. I believe the number of explorers and the number of persons to whom we will have to trust for the development of our mining territory would be greatly increased if the proposal of the member for Algoma (Mr. Cumberland), or rather that of the member for North Bruce (Mr. Sinclair), which I much prefer, to give locations of 40 acres, were accepted.* It would greatly increase the number of men who will go in, who, without having any large amount of cash in their pockets, are likely to display the greatest enterprise in actual explorations. This would be done by giving greater facilities to this class of men—by giving them the power to buy, in other words, by giving them the power to buy a less quantity of land than is provided for in the bill.

Small locations.

There are those who say that the occurrence of minerals in Ontario is not of a nature to warrant the government in permitting sales of small locations, such as are provided for in the laws of British Columbia and the United States ; but in the light of recent developments in the silver mining district of lake Superior, and the copper mining district of Sudbury, it does not seem that a location of $20\frac{2}{3}$ acres (1,500 feet by 600 feet) is too small for the carrying on of successful operations. Everything depends on the richness of the lode or deposit, and if the conveniences of the prospector or miner are better suited with the privilege of buying 40 or even 20 acres instead of the present minimum of 80 acres, the country stands to gain rather than to lose by accommodating him with the smaller area. It may be assumed that, within reasonable limits, the larger the number of mines with separate and independent owners there are in operation upon each known lead, the more satisfactory will be the progress of mining industry in the country. But much will depend on the amount of capital that the mine-owner puts into his business, and the energy and skill with which the work is carried on. One strong company, if not hindered by a too narrow area, may employ more men and take up more minerals than half a dozen weaker concerns ; and, providing that working conditions are imposed and enforced, it does not seem that a useful purpose can be served by a provision the effect of which may be to bar the profitable investment of capital.

Survey of locations]

The cost of the survey of locations is regarded as a grievance by some prospectors, more especially that provision of the act which requires that a location in unsurveyed territory be connected with some known point in previous surveys, or with some known point or boundary, at the cost of the applicants. It may happen that a mineral discovery is so far distant from previous surveys or other known point or boundary as to make the cost of running a connection line very expensive, and in a case of this kind the practice of staking claims might be recognised until such time as the taking

* Mr Cumberland had suggested the sub-division of locations into sections of 80 acres each, and this suggestion was accepted by the commissioner.

up of other locations brought the cost of surveying a tie-line, by apportionment, within the limit of a reasonable charge. It is essential, however, that all locations for which patents have issued should be laid down in the office maps of the territory in the crown lands department, and no patent ought to issue until a survey is made connecting the property with some corner of the public surveys or some permanent monument or natural object. The applicant for a staked claim might meantime be protected in his rights, with leave to work it upon payment of the purchase money unless such work was in fulfilment of the conditions for taking out a patent; but protection without development ought to be for a short fixed period. Concession of the right to stake or mark out locations in surveyed territory is a matter of less consequence, as no difficulty is likely to be experienced in procuring surveys; still, if this plan enabled prospectors to file claims with greater readiness and certainty, it ought to be freely allowed. Either an official survey, or such other description of the location by reference to some natural object or permanent monument as will identify it, might be accepted as satisfactory in making the application for a claim.

Working conditions.

It is easy enough to exact conditions for improvement of a location between the time of applying for it and the issue of the patent, and the practice which prevails in some countries of requiring an expenditure of a specified sum of money for labor each year for a term of years before granting the patent is commendable. But where land is sold outright, without reservation of any kind, it is difficult to apply working conditions. And it is doubtless true that a very large proportion of the mineral lands sold in Ontario during the last forty-four years is held in a state of non-development. The owners cannot be forced to undertake mining operations, and prospectors have no rights in any discovery which they may make upon the lands. A number of persons examined before the Commission have recommended a change in the law whereby parties holding mineral tracts in a state of idleness should either be forced to begin and carry on mining operations themselves, or concede the right of mining to others upon a royalty. But both of these plans are open to the objection of interference with vested rights, and therefore contrary to the genius of our legislation. The best and perhaps the only remedy for the evil would seem to be that which has been adopted in New Zealand and South Australia, viz., the resumption of such unworked lands by the government as are believed to be valuable for mining purposes, upon payment of a reasonable compensation and holding them for re-sale subject to development conditions.

The New Zealand and South Australia remedy.

Reservations and royalties.

There are some persons who favor a return to the system of reservations and royalties abandoned and made void by the act of 1869. By that act all lands for which patents had issued were declared to be thenceforth free and exempt from every royalty, tax or duty, and the gold and silver reserved in any patent theretofore issued were declared to have passed with the lands in fee simple to the owners. The act also declared as to the future that no reservation or exception of gold, silver, iron, copper or other minerals should be inserted in any patent granting lands in this province sold as mining lands. Those interests, having been surrendered by the crown, cannot be

regained except by purchase from the private holders, and justice would require the taking of this step if it was decided either to reserve minerals or impose duties upon them as conditions in the sale of public or mining lands hereafter. To place a burthen or a restriction upon the mining industry in one section of the country from which it has been freed in another would be a fruitful cause of irritation. But even if the policy of restricting and burthening the industry could be generally applied, no one can believe that greater activity would follow. One might with as good reason hope to see a man's locomotion improved by attaching a cannon ball to each of his legs. At any rate, as long as mineral development in Ontario continues to depend largely upon investments of foreign capital, and especially of American capital, a liberal policy must be followed; mining lands must be not less free here than in the United States, where with the single exception of New York there is neither reservation nor royalty. So, also, as regards the leasing of mineral lands, the influence of the United States system would make its adoption well nigh impracticable here.

The leasing system.

Underground boundaries of mining locations

The underground boundaries of mining locations are not fixed by the law, and were a dispute to arise great difficulty might be experienced in getting a decision. It is only in the case of claims in mining divisions that the law pretends to say what these boundaries are, and what it does say is as mysterious as the utterance of an oracle. The act of 1868 provided that "the ground included in every claim shall be deemed to be bounded under the surface by lines vertical to the horizon;" and while this clause is retained in the act of 1869, another is added the effect of which appears to be to give to the licensee the right of following the vein laterally to any workable extent. "To the depth to which the same can be worked" are the words used, but by some lawyers this phrase is construed to mean only as far as the vertical boundary. The liberal construction is doubtless the proper one in the interests of miners.

Health and safety of miners and security of their claims as wage-earners.

In another and more important respect the act is also defective, viz.: provision for the health and safety of miners, and security of their claims against employers. It may be that the general provisions of the Master and Servant act, the Mechanic's Lien act and the Wages act afford sufficient facilities to mine workers in the collection of wages, although there are circumstances of mining employment which may be thought to demand special legislation. But as regards the health and safety of miners, little or no protection is afforded by our laws applicable to mining in Ontario; and although no law can ensure workmen against the occurrence of accidents or the effects of foul air, it is none the less necessary that every possible provision for their health and safety should be made by the law. The British and the New Zealand regulations are valuable models of this kind of protection.

Annual returns to the government.

If the law also required the owners of working mines to make yearly returns of their operations to the government, showing the extent of mining work done, the quantity and value of ore or other material raised or quarried, the quantity shipped to market, the number of persons employed and classified rates of the wages paid, together with plans or maps of the mines showing

exact measurements of the work, it is believed that a useful public purpose would be served thereby.

The prevention of forest fires is a matter of supreme importance to the country, but, unhappily, it is one in which the interests of the general public and of the explorers for minerals are not identical. Where the land is heavily timbered and the soil covered with moss and decayed vegetation, as is the case in extensive regions throughout the northern part of the province, it is difficult to prospect for ore-bearing veins; and although it would be unjust to charge explorers with purposely setting out fires for the object of facilitating their own quest, it is an undoubted fact that a burnt district is more easily searched than one covered with primeval forest. The explorer's interest does not lead him to exercise great care in the prevention of fires, and he is more likely to view their outbreak as a good turn done to himself rather than an evil one to the country. The law to preserve forests from destruction by fire, being chapter 213, R. S. O., 1887, is ample enough in its provisions; but it is generally supposed to apply only to lumbering parties and railway companies. To remove this misapprehension and make the law known to other parties whom it specially concerns, it is suggested that prospectors for minerals be required to take out an annual license to explore, issued by the department or any local land agency at a nominal fee for a specified territory and having a copy of the act attached thereto; and that in the case of a party of explorers employed by any person, or company of persons, the requirements of section 8 of the act should apply.

Forest fires in mineral districts.

A suggested remedy.

The mining division system of the present law has failed so hopelessly in practice that it does not deserve serious consideration; nevertheless some features of the system are worthy of being retained in the act, such as those which relate to the inspection of mines and the observance of conditions under which claims or locations are held.

The mining division system.

William S. Gibbon—The mining laws at present in force I think operate against the poor prospector, and retard the development of the country. I think it would be wise to copy the mining laws of the United States, and allow the prospector to put down his stakes and mark off so many chains and require him to do so much work every year. The taking up of land to hold for speculative purposes has just commenced in this section, and if allowed to continue will tend to retard the development of the country. I think the proper remedy would be to compel the performance of so much work, say for five years, and at the end of that time the prospector should be given his patent in fee simple; I think that would be better than giving a lease, as is done in the case of timber lands. If allowed to stake out claims as in the United States, the result would be a great increase in the number of prospectors.

Encourage the prospector.

Thomas Frood—Under the present mining laws the poor man is at a disadvantage; he is required to pay for the land in cash when he makes his application, and very few prospectors are in a position to do that. I have had to give away 95 per cent. of mineral land to secure the other 5 per cent. I think it would be wise to place mineral lands on the same footing as timber lands. When an explorer makes a discovery he should send information to the crown lands department; the department should then send an expert to examine it, and if the discovery proved to be of value the prospector should receive a percentage of what the property sold for at public auction. All mineral lands should be advertised for sale once a year and sold. By adopting that system the country would receive the benefit of the speculative value, while at the same time the prospector would receive a fair recompense for his discovery. Conditions might be imposed compelling the performance of a certain amount of work, or if the government thought proper a royalty might be paid. The same principle is carried out in regard to the timber

The speculative value of mineral land.

sales, and I think the best possible prices are realised. In dealing with this matter the amount of purchases by companies should be limited. I think more capital would have been invested in the Sudbury district if speculators had not been allowed to buy up the land. I have had no experience as to the working of the American mining law, but I think I may add a suggestion to what I have already said, that the prospector should be allowed to take up a small quantity of land, say 10 or 12 acres, instead of as now being compelled to purchase 80 or 160. I also think it would be well for the government to place one officer with a good deal of authority at Sudbury and another at Port Arthur, to deal on the spot with questions of title and other matters; it would save a great deal of trouble, and prevent a great amount of litigation in the future.

Small or large locations.

Local administration.

Henry S. Hedges—I think there ought to be some change in the law, so as to protect poor men like myself. I think the prospector should have the right to stake out his claim, and should be protected till he has time to purchase the property at the end of a number of years, he having to do a certain amount of work.

The right to stake out claims.

James Miller—I think the prospector should have the right to stake out his claim, and hold it by doing so much work each year. I also think it is a mistake to sell large tracts of land to speculators. I do not think it would be unjust to have the right of prospecting on vacant private lands, the prospector in the event of making a discovery to have a share in the find.

Prospecting on vacant private lands.

R. E. Bailey—I live in Milwaukee and I am at present and have been for a number of years engaged in mining. I have been prospecting since 1868, during four years of which time I was in South America—Chili, Peru, Equador and the United States of Colombia. I have not been engaged in mining all the time since 1868. By trade I am a millwright, but I have always been engaged setting up mining machinery. While I was in South America I was exploring. After coming back from there I went to the mining districts of Colorado, Idaho and New Mexico. In every mining district I have been in I have always done prospecting and acquired property. I came here a year ago on the 24th of July, and am now acting for the Algoma mining syndicate and the Imperial land and mining syndicate, both of Milwaukee. The mining laws here are not fair to the prospector, and some way should be devised to protect him. Land should not be sold to be held for speculative purposes. Every man having a claim ought to be compelled to do a specific amount of work every year; that, I think, would be better than taxing mining land. The United States mining law works well, and might be copied here. It is necessary that the prospector be protected, as capital will not explore. There is one matter I would like to mention. In regard to the Batchawana claim, I have paid for the land what the government asked. I have employed a land surveyor and paid him for making a survey, yet they will not grant me my patent till I go to the expense of connecting that with a point on their survey. If I happened to be 30 miles away from such a point it would cost about $3,000.* If the American laws were adopted and we were allowed to stake our claims that would be done away with. All properties around here are undeveloped. The development of the property is what gives it value; I do not therefore approve of holding undeveloped properties at high prices, as it retards development. Seven or eight mining men came to this place from the Rocky mountains, and went back on account of the mining laws. Lands should not be allowed to be located as mineral lands till the prospector has made an affidavit that he has found mineral upon them and has produced specimens.

Protection for the prospector.

Connecting a location with the departmental survey.

Holding undeveloped properties retards the mining industry.

Right of location.

Æneas McCharles—As the laws are at present the prospector has no protection at all; he is liable to have his claim jumped before he can secure it. There should be a limit put to individual sales so as to prevent the speculative holding of land. Some mode should be provided whereby a prospector might find out without delay what lands are located. Such means should be provided at the local office, and as soon as a lot is taken it should be so marked at once; at present it is very difficult to find what lands are taken. A supply of maps should also be kept at the local office for sale at a nominal price to those wanting them. Some Americans came here and wanted to get maps, but were unable to get them and had to pay a surveyor $26 for what they required; that is not right. Instead of allowing the staking of claims along the vein, I think it would be better to allow the prospector

Speculative holding of land.

Local agencies to give information.

* This estimate is doubtless too high; but in a speech made by Hon. Stephen Richards in the legislature, December 11, 1868, upon the mining bill of which he had charge, he is reported as saying that a single line run from Sault Ste. Marie to Thunder bay, at a distance of about 18 miles from the coast, had cost the government from $40 to $70 a mile.—A. B.

to take up 40 acres if he desires or allow him to take up as many claims as he likes, provided he does so much work on each claim of 40 acres. It should be compulsory to do so many days' work; I doubt whether it would be wise to fix the amount in money. If a money basis were adopted I think a man taking up 160 acres should be compelled to expend at least $500 the first year, the expenditure to be to the satisfaction of an officer of the government appointed for that purpose. The prospector should have 90 days after he has staked his claim to secure the property; he should have that time before being called upon to make any payment. Forty acres should be the smallest and one hundred and sixty the largest quantity of land sold to one party. I think that in the case of lands which are held without being developed the prospector should have the right to go on them and prospect, and have a third interest in any mineral he finds. The government should lay the country out in mining districts after minerals have been discovered, and they should then build roads as they do to encourage agriculture. Experts should be appointed to decide what sections should be laid out in mining districts. In my opinion good roads do more to develop the country than anything else, and I think the government would do better to build roads than to bonus a railway. Americans do not seem to like to go out of their own country, but I think they are beginning to come here; one told me the other day that he had just put $25,000 in Michipicoten. Where a prospector locates a claim over six miles from a surveyed township he should be allowed to stake his claim and should not be compelled to connect with the nearest survey; it is not fair for one man to have to bear the expense when others may benefit by tying on to him.

Small locations and compulsory development.

The right of prospecting private lands.

Public roads.

Staking claims in unsurveyed tracts.

Edward Norris—I think the prospector should be allowed to stake out his claim as is done in the States. As it is now a great many discoveries are made which never come to light on account of the fear of being jumped. Take the case of Frank Vallequette, who has been exploring this district for the last ten or twelve years. He has discovered eight or ten good things, but will not tell where they are because he had a claim jumped once.

Security of claims.

W. H. Plummer—I am a merchant and have been living at Sault Ste. Marie about twenty-five years. I have interested myself in mining matters somewhat, taken shares in them, assisted to develop them and so on. At present I am not heavily interested in mining property. As far as my judgment goes the Ontario mining laws are as good as they can be; still I think it would encourage prospectors very much if the government gave them an option, provided they did *bona fide* development work. I do not think holders of wild land would object to prospectors going on their property, or would refuse to reward them for anything they might find. I don't think the people of this district would object to a law of that kind, but the prospecting should be done under certain conditions.

Giving prospectors an option.

Private lands.

Thomas A. Towers—The government should limit the quantity of land sold to one party. As the law now is the prospector has to keep his discoveries very quiet, otherwise he will be jumped. I think he should be allowed to stake out his claim and go to the nearest office and secure his rights for a time to enable him to find means to purchase it. The whole of Denison township was bought up by parties in Toronto who never were on the ground and who knew nothing about it, excepting the report of the find on Vermilion location. I don't think it is right to allow that. If a district is likely to be a mining district I think it would be right for the government to run lines for the prospectors to tie on to, and I think surveys should be made by the government.

Prospectors and speculators.

Tying lines.

A. G. Duncan—The Vermilion company owns about 2,700 acres of land; 2,100 acres they got from the government, and the balance from private parties. They commenced operations last winter, some time in January. I have had no former experience in prospecting or mining. I think if the government were to proclaim this a mining district the law would be satisfactory, but as it now is I don't think it gives satisfaction. Where a large quantity of land is being held prospectors should be allowed to go upon it and develop it on a royalty. The prospectors themselves seem to favor the American law, and say they would prefer to be allowed to stake out their claims. The holding of large quantities of land is detrimental to the interests of the country, and as far as I am individually concerned I would not object to a law allowing the prospector to go on all lands so held and work them on payment of a royalty. Many people come into the country, but finding the land all taken up they go away and do not come back again at all.

Mining districts.

Large holdings an injury to the mining industry.

Henry Ranger—The laws are not altogether fair to the prospector. I think he should be allowed to stake out his claim and be given a reasonable time before

Claim-jumping.

having to pay for the land. I speak from experience, having had a claim jumped before I could manage to secure it.

Prospectors on private lands.

B. E. Charlton—Our company has adopted the policy of encouraging prospectors by allowing them to work under a royalty, the rate of the royalty being determined by the circumstances. The mining laws are satisfactory as far as we are concerned. To work a copper mine takes a great amount of capital, and therefore a large quantity of land is necessary in order to be able to do anything. In the case of free gold, it could of course be developed with a small capital. I do not think however that it is in the interest of the country that large amounts of land should be tied up by one company. I think it would be a wise provision to prevent the taking up of mineral land till mineral is shown to exist upon it. It would be well to devise some judicious means of preventing the tying up of land.

Size of location.

Discovery should precede location.

A whole township taken up and held by speculators.

James Stobie—I live in the township of Johnston, district of Algoma. I have had experience in mining and have been engaged in exploring in this district for the last three years. I am interested in the Dominion mine and am a shareholder in the Vermilion. I do not think the mining law is fair. As it is at present the whole of Denison is taken up and is being held by speculators. I think it would be to the interest of the country if the prospector had the right to go on land so held, and if he makes a discovery an interest should be given him. In granting a patent of agricultural land the same right should be reserved to the prospector. Such an alteration in the law would tend to encourage prospecting and develop the country perhaps more than anything else. At present the prospector is at the mercy of the capitalist. Some way should be devised to protect him till he has had a reasonable time to acquire the property. The quantity of land sold to one party should be limited. In the case of iron more land should be allowed, as more is required for works, etc. ; but on all lands sold the government should insist upon development. If the law compelled owners of properties to work them I don't think the holding of large tracts would interfere with development, but if not worked the land should be open to prospectors and if anything was found the discoverer should have a stated interest in it.

Prospecting private lands.

Small locations and development.

Development.

Robert Hedley—I think there should be some law compelling the holders of land to develop it, and if they did not comply with the conditions the land should revert to the government.

The prospector does not get fair play.

John Babcock—The mining law does not give the prospector fair play. He has to keep his find very quiet and has to give a man the big end to secure it for him. The prospector should be allowed to stake out his claim. Under the present law I have known a man to have three claims jumped. There should be a local office where the prospector could register his claim, and also where a man could find out what lots have been sold. The size of a copper claim should be, I think, about 80 acres. For gold and silver the claim should be 100 by 200 feet.

Size of claims.

Conditions of holding claims.

Robert McCormack—On gold and silver veins the prospector should be allowed to stake his claim as is done in the States ; he should do so much work and at the end of five years be entitled to his patent. For copper and iron the claims should be from 160 to 320 acres.

Staking out claims.

Charles Kettyle—I think the mining law should be so amended that the prospector might be allowed to stake out his claim as is done in the States, he to do a certain amount of work every year.

Inadequate protection for the prospector.

P. C. Campbell—The present mining law is not satisfactory ; there is not any protection for the prospector at all. The man who makes a discovery has to make an affidavit, and the man before whom he makes it may telegraph to a friend in Toronto and have the location taken up for himself. I would suggest that the prospector be allowed a certain time to secure his location, that he be obliged to do a certain amount of work, and that while he is doing the work no one be allowed to buy the location over his head. The prospector should have the right to go on all lands held for speculation and should have an interest in anything he might find, or be allowed to work it on a royalty. I think it would be right and fair to give the present holders of land a certain time to explore and develop their lands before such a law should be put in force.

Discoveries on private lands.

Location and improvement of claims.

Dr. Edward Peters—In regard to the mining laws, I think the prospector should be allowed to stake out his claim, as in the States, he to do certain improvements ; or perhaps it would be better if he had to do so many days work before he became entitled to get his patent.

Francis Sperry—The burning of the timber is injurious, as it is a very important thing in mining. I think as a rule prospectors are very careless about fire, but I don't say that they burn the bush purposely to expose the rock. To carry on mines like those of the Canadian Copper company it is a necessity that they should have large quantities of land. Mining, to be carried on successfully, requires a large amount of capital.

Protection of timber in mineral districts.

Francis Andrews—The destruction of the forest by fire is a disaster; it will increase the cost of timber, and is therefore a serious injury to the mining industry. I know that as a rule prospectors are not very careful about fire, but I don't think they would fire a woods on purpose. I think that unless persons holding land employ so many men, or expend so much each year in wages, they should be taxed for improved land. Such legislation as that would prevent the tying up of whole sections of the country. The prospector should be allowed to stake out a claim of 80 acres, or at the outside 160, and he should be compelled to do so much work every year. I don't think the occurrence of minerals here is favorable for the staking of claims on the vein. I think the miners should have the right to take timber of small size.

Speculators and prospectors.

S. J. Dawson—In the dry season when the mosquitoes are bad prospectors are in the habit of making smudges, and I think are not very careful about putting them out, and that causes many fires. As a country becomes settled it is well to pass very strict laws as to the setting out of fire, but in the case of prospectors it is a difficult matter to deal with. The only thing to be done, it seems to me, is to have them thoroughly instructed in regard to the danger, and create a public feeling against carelessness. In some instances prospectors have no objection to fire, as it uncovers the rock, and they have been known to start the fire for that purpose. Where fire is set out in that way there should be some punishment awarded, but the great difficulty would be to ascertain whether it was set out purposely or whether it was an accidental fire. I would consider that if a prospector went away leaving his camp fire burning he was guilty of criminal carelessness. I do not think the mining laws of Ontario can be improved, except as to the taking up of large blocks of land, which I think has a tendency to prevent development, and to keep out *bona fide* miners. It is difficult to say what the limit should be, but whatever is set upon it should be compulsory to do a certain amount of work, failing which the land should revert to the government. I think a quarter section would be a fair limit, but for wood supplies I would not limit them to less than 400 acres: too small a limit would be injurious. I don't think the staking out of claims would do well in quartz mining, and I don't believe it would work well here. I do not approve of a royalty; I think a royalty of five per cent. would put a stop to mining.

Protection against forest fires.

Limiting the size of locations and requiring development.

Royalties.

Thomas Marks—I think our mining laws are about as good as we can make them; I do not think we can improve them by making any change. I think where no pine exists the burning of the forest does no harm; in fact I think it does good; the second growth soon springs up and is quite as good as the original forest. I would prevent the burning of the pine as far as possible. I would put it in the market, and it would soon be cut and run down the rivers. Nearly all our agricultural lands here are cleared after the fire has run through and it is hard to get men who will go in and clear the heavy forest. Except for the loss of the pine the fire does very little harm. The second growth is finer than the first, and takes only about eight or ten years to grow up.

Forest fires

Peter McKellar—I think the mining laws are good. I do not think it would be wise to compel people to work their land; it is quite enough to have to pay the present taxes. I am interested in about 10,000 acres, the tax on which is one cent per acre. There is plenty of country that has not been explored, and in that the prospector might be allowed to stake out his claim as is the practice in the States. But I think the present tax is sufficient to prevent persons buying land and holding it for speculation. Lots of the land is every year sold for taxes.

Taxation of mining lands.

William Margach—The Americans who come to my office are willing to pay for their land, and express themselves satisfied that it will equal the country south of the boundary. The land on the south side of the boundary is homestead, and they have to get a man to live on it a certain length of time to get a patent. At the present time you will see between Basswood lake and Tower a number of shanties that have been abandoned; the windows and doors of all are the same, so that they may be removed and put into another shanty. The parties occupying make just a little clearing, so that they can swear they have made the improve-

The United States location system.

ments. I am supposed to locate mining land, but I guess they sometimes get the start of me. They have twelve months under the free grant system during which the government can do nothing. I think there should be some alteration in the law. Along the Whitefish valley there is some good land, and in the midst of it there is mining land; part of that is a free grant district. The township of O'Connor is free grant, and also half of the township of Gillies; the south half of that township is reserved for mining. I don't know of any case as yet where wrong has been done by holding large quantities of land. It would be an advantage if the government required development to be done on all land taken up.

Land within Whitefish valley.

William Plummer—In regard to the mining laws, large tracts of land should not be allowed to fall into the hands of persons to be held for speculation; it locks up the property and stops prospecting. The prospector should be allowed to stake his claim as is the case in the States.

Mineral lands should not be held for speculation.

James Conmee—I think the mining laws should be modified. More protection should be given to the prospector. He should be allowed to stake out his claim and should be given a reasonable time to secure it. The amount of land sold to one party should be limited, or the tax should be increased so as to force those holding on speculation to sell or develop their property. I think it would be well for the government to require the prospector to do a certain amount of work each year as is done in the States.

More protection for the prospector.

Development work.

William Murdoch—I think the law should be so altered as to compel every holder to expend $500 on his location. I do not think it would do to charge a royalty; that would act as a damper.

Locations and royalties.

W. H. Laird—I resided here from 1879 till last November, and am still interested in quite a number of mining properties. I think the mining law should be so amended as to compel people to do improvements from year to year, say for three or four years, till they got their patents. Perhaps if people wanted to buy they should be allowed to do so on payment of $5 or $6 an acre. If they were forced to spend $500 or $600 it would prevent the holding of locations for speculation. It might be better to compel the doing of so many days work instead of expending so much money. In making surveys the government should put in iron posts, as there has been a deal of trouble around here on account of a great many of the posts getting burned. Something should also be done to prevent the burning of pine.

Mining claims should be improved.

Surveys.

William Russell—As it is I think the explorer is protected to a great extent by the department, but I think a time limit should be arranged for the prospector to secure his location. Fifteen days should be allowed him to file his claim, and a single location should be forty chains on the course of the vein as far as the vein can be enclosed. The prospector should be required to mark two or three trees, putting the date upon them, and should refer to those trees in his application; he should then be protected for a reasonable time. I do not think one man should be allowed to hold more than one claim.

A time limit for the prospector to file his claim.

D. F. Burke—The mining law of Ontario has locked up a great deal of territory. There are about 800 silver locations taken up, and it is doubtful if 30 of them are being worked. I think it would be well to have the law about the same as in the United States; that would protect the prospector and do justice to the capitalist. Iron stakes should be put down at the corners instead of wooden ones as now; there is great difficulty in finding the stakes, and it would save people thousands upon thousands of dollars in the future.

Too much territory locked up.

Iron stakes for surveys.

W. N. Montgomery—The American mining laws would be better for the poor man; the law here is first rate for people that have money, but it is plain to be seen that it operates altogether in favor of the rich man.

The law favors the rich man.

Henry Rothwell—The prospector should be allowed to stake out his claim, and I think the claim should be about half a mile on the vein and about 200 or 300 feet wide. He should be compelled to do certain development work every year; $100 a year, as in the States, would I think be about reasonable. Speculators should not be allowed to take up large tracts for speculation. It is often very expensive to get surveys made, and I think the government should do the surveying. It would be a good plan to survey the townships as they are being prospected.

Claims and their development.

Surveys.

T. H. Trethewey—I do not think the mining laws are satisfactory. The law should be so that if after the lapse of a certain period of time a certain amount of work was not done the land should revert to the government, and the patent should not be granted till the required amount of work was performed. It would

Development should precede the patenting of locations

be perhaps as good if the government leased the land at such a rental that holders would have to work it or throw it up. As it is now nearly the whole country is bought up and held on speculation. The adoption of the American law allowing the staking of claims would answer I think, provided the locations could not be held without being worked. People here are asking from $1,000 to $100,000 for their locations, and there is not one dollar's worth of work done on them. Speculative holdings.

Duncan McEachren—The prospector under the present law is not fairly treated. The law should be altered so as to allow him a reasonable time to secure his claim. The land should not be allowed to get into the hands of speculators. The prospector should be allowed to stake his claim and should have a fixed time to perform a certain amount of work. I am satisfied with our law if the jumping of claims could be prevented. The prospector should have a reasonable time to secure his claim.

Ambrose Cyrette—I like the present mining law, but I think the poor man should have time to secure his claim.

Walpole Roland—I think the mining laws are satisfactory, except that the government should make more extensive surveys in the mineral belts. At present it is often a hardship on the poor man to get his claim surveyed. The running of a north and south line and an east and west line would answer. The blocking out of the land as in the North-west would do. Iron posts should be put down as great trouble is caused by the wooden ones being destroyed by fire. The government could raise the price of the land and so pay for the surveying. I do not think I would allow the prospector to stake out his claim: he should be allowed to pre-empt for a certain time, and if he had not done his amount of work by that time it should then revert to the government. No title should in any case be given till the amount of work is done. Surveys in the mineral belts. Pre-emption of claims.

John K. Wright—I am very well satisfied with the provisions of the Ontario mining act. The only fault I have to find with it is that it is too liberal in allowing parties to acquire a too large area of territory if they can pay for it. Large locations

George Mitchell—I think the mining act should be amended so as to limit the area which could be taken up by one party. Under this change the country would be more thoroughly prospected than it now is, and especially would this be the case should successful development ensue in the district. Small locations favor thorough prospecting.

A. R. C. Selwyn—I think the regulations as to the sale of mineral land in Ontario are very bad; the selling of large blocks of land is, I think, wrong. It passes the land into the hands of speculators. It would be well to limit the amount, and no land should be sold as mining land unless a vein or other workable deposit has been found on it. The limit should depend upon the extent of the deposit that is going to be worked. I would accompany the sales by conditions as to working that could not be evaded. It would perhaps be better to give the land to anyone who would undertake to develop it. I would allow anyone who was willing to work to acquire the right to do so at a nominal price, but the conditions as to working it I would make very strict. The quantity of land would not so much matter if the conditions for working it bore some relation to the extent of the area; the larger it is the more work that should be required to be done. I would not allow as great an area for gold as for copper, galena, iron and other minerals. I think 160 acres is quite sufficient for any mine; for gold and silver I do not think so much is required, but purchasers should have enough for the necessary buildings, timber, roads, etc. It would be a good regulation to allow no land to be taken up till a mineral vein has been discovered upon it. I have heard a great many complaints, and I see myself that the system of buying up large tracts on speculation has operated very injuriously. I think mining properties are held too high and that this tends to retard development; of course I have no personal knowledge that such is the result, but that is what I have heard. All mineral claims should either be worked or abandoned. Regulations and conditions. Area of mineral locations. Claims should be worked or abandoned.

E. V. Wright—I am perfectly satisfied with the Ontario mining law. I think, however, there should be a limit to the amount allowed one party; that limit would have to be fixed by circumstances. I do not think it is right that one person should be allowed to buy up a whole section of the country. I think if a man finds a vein, and it turns out richer further on, he should have the right to take up the richer part; he should have the right to pre-empt another claim. Size of locations should be fixed by circumstances.

B. T. A. Bell—The Mining Review receives reports from Port Arthur, Sudbury, Lake-of-the-Woods, Madoc, the Perth district, the K. & P. district, the Ottawa valley and the petroleum, salt and gypsum districts. There is a growing desire for informa- A growing desire for information.

tion in connection with mining matters, as is evidenced by the increasing number of our subscribers and the increasing number of people asking for information about mineral lands in Ontario. The collection of minerals sent to Cincinnati by the Ontario government did a great amount of good in this regard. The distribution of information on mining matters is of vital importance to the mining interest. It attracts the attention of parties in the United States and Great Britain, and even in Germany. I think our mineral lands should be reserved by the crown. I think the present system of selling lands unconditionally is opposed to the development of the country. Development to a certain extent every year should be compulsory. Any mining regulations which permit the acquisition and control of large areas of land upon payment of a merely nominal price is undoubtedly a most favorable arrangement for capitalists and speculators, but it is one which is in every sense opposed to the best interests of the people at large. At present extensive districts are locked up in a few hands and no one is permitted to operate upon them unless he can afford to purchase the land at an immense advance upon its cost. Everyone who has tried to influence capitalists to invest in mining ventures knows how easy it is to raise mining capital alone, compared with obtaining money for a scheme weighed down with a preliminary purchase of lands often at ten times the sum required for actual operations. In our phosphate district cases are found where lands originally purchased from the government for a few dollars per acre have been resold at $10, $100, and as high as $400 an acre. One tract of land bought for $5,000 was resold for $16,000, then at $160,000, and part of it again for $450,-000. The interest on such large sums tends greatly to discourage investment, and the usual failure of mining enterprises loaded with such a weight of dead outlay is the most serious check on the development of the mining industries. If capitalists were permitted to lease upon royalty just so much land as they could work and only for such periods as they continued to work, and if the poor prospector could lease the area on which he had made a valuable find and be at no expense beyond the cost of working, then we should see a vast increase in mining matters; the revenue from royalties would be a constant and important source of income, and the people would cease to barter away their natural rights for a paltry mess of pottage.

Mineral lands should be reserved by the crown.

Speculative prices for lands discourage investment.

The royalty system and small claims.

John Stewart—In a country where there are minerals it is necessary to divide the mineral and the farming interests. In selling lands the minerals should be reserved for the use of miners. A man should be allowed to locate his claim as under the American or Dominion lands system; he should be required to do a certain amount of work every year, and after a certain time he should get a twenty-five years lease with the option of a renewal for a further term of twenty-five years at a certain royalty. If the minerals were in the hands of the government we would be dealing as a rule with gentlemen, and not with farmers or speculators, some of whom are related to the species hog! The location of a mineral claim should be made first on the ground by the discoverer or prospector, and then in the local land office. It should be measured on the length of the vein, say about 1 500 feet, the boundaries being parallel with the walls of the vein. The discoverer should be allowed to take two claims adjoining each other. The miner should have the right to follow his vein by continuous workings wherever it goes, as is the case in the western states and on British crown lands. To show the injustice of not being allowed to follow the vein, I may mention the case of a Scotch company having purchased a property and spent $500 000 on it. It was found that the vein dipped at an angle into the adjoining property; this property was secured by another party who stopped their working. He then leased the works of the Scotch company and continued the work. The Scotch capital was in this way driven out of the country. Several Ontario mines are in similar condition on this account. The selling of minerals with the soil is bad; the minerals should be reserved by the government. If a man buys the land there is no reason why he should get the minerals too. If a man buys or leases for iron ore, the gold, silver, copper and other ores and minerals should be reserved. In the case of iron the location should be larger. In regard to lands already patented, my idea is that an act should be passed to enable an explorer to locate a claim wherever minerals are if the owner will not work them, he paying the owner a royalty of say 5 per cent. and $2\frac{1}{2}$ per cent. to the government. Companies holding a large area should be compelled to take a fixed royalty as stated, or be forced to work the mineral properties. In Norway and Sweden the law is this way, and no property there need remain unworked because the owner will not work it. I cannot say whether the government there originally sold the land in fee simple. I do not think that what I have suggested would be an injustice, as when selling the land the government got nothing for the minerals;

The leasing system.

Location of mineral claims and right to follow the vein.

Reservation of minerals.

Minerals in private lands.

it would be a just law and would be no more than a tax raising revenue for the promotion of the mining interest. It would not be confiscation; the government would not resume possession of the land, and the owner would be paid a royalty. The law that tends to the development of the country is the best law we can have; it is in the interest of the community generally. Confiscation at the death of the owners would not be so unjust as the present system. Where government reservation exists the mining industry prospers, and where there is no compulsory development it does not. In the west it has prospered because the miner has had to spend $100 a year in work to hold his claim; but it is found there that when once the patents are issued they hold the lands on speculation and don't work them; hence the lease system is in the interests of labor and dovelopment. Working conditions.

A. J. Cattanach—I do not think that the policy of selling large blocks of land has retarded development or has hindered prospectors. As our mining law has been since 1868 the governor in council can proclaim a mining district and appoint inspectors. Mining districts. Under that law they did proclaim the Thunder Bay district and Mr. Borron was appointed inspector. Under that law all a prospector had to do was to stake out his find, he had the right to prospect on any government land, and it was the license inspector's duty to give him a certificate on payment of a fee of $5. He could then renew his certificate from year to year on payment of a fee of $5, and go on taking out the mineral without paying any royalty or purchase money or anything except this $5 a year. At the present time the government can proclaim any district. In the Thunder Bay case the prospectors did not avail themselves of the provisions, and at the request of Mr. Borron himself the office of inspector was abolished. He did not care to hold the office as he was not issuing any licenses. All that would be necessary to put that law into force would be to appoint an inspector. I think it would be well after lands have been patented five years, if the owners do not develop, that any person should be allowed to go on them to prospect. Prospecting on private lands. I do not think such a law should apply to lands already taken up as it would be an interference with vested rights, and would tend to frighten foreigners who supply nearly all the money that is spent in mining. There should be a fair arrangement, wherever the principle could be applied, by which the discoverer and the owner might be both protected. It is a very difficult matter to deal with; but I think it might be done by giving the discoverer the right within a limited time (say a year) of working the find, subject to the payment to the owner of 25 per cent. of the profits if the owner did not exercise the option of working it himself within the same time and giving the discoverer the same percentage of profits—either of them being at liberty to take up the work on his own exclusive account if the other discontinued work under circumstances which would forfeit a claim under the general mining laws. I think the system of taxation has been an utter failure in regard to the development of mining properties, and the legislature in 1886 recognising that fact passed an act reducing arrears fifty per cent. and future taxes from two cents to one cent an acre. The taxation system. The statistics show that only a small portion of the taxes are realised at tax sales; only about one-third or one-fourth of the actual amount of taxes is obtained from the sale of the lands. I do not think, as I have said, the sale of large blocks of land has retarded development, and I think it should be continued. Large locations not objectionable. I have had some experience of the difficulty of getting money for mining operations, and I suppose one of the reasons for wishing to have large properties is that the chances for getting money will be better. When mineral is discovered all the adjoining land is taken up, and the same motive operates with those who put money into mining. I think on the whole that more good than harm has been done by the sale of large blocks. The license system has proved altogether a failure in this country. Since 1869 we have had two systems in operation—the license system and the system by which a person can buy outright. The license and sale in fee simple systems. Everyone wants to buy, and the conclusion is that the license system is not considered the best by practical men. I would permit purchase of land without limit as to extent, but with provisions as to development.

William Ward—I think it is the duty of the government to get the best price it can for the land. I do not think the prospector is at a disadvantage; the department gives him reasonable protection. I think that under the present law he is fairly treated and protected, but I do think it is a mistake to sell large blocks without some condition as to development. Conditions of development desirable. If the government laid it out as a mineral country it would only be a proper thing to have it sold by auction, as timber limits are.

Size of locations and prospectors' interests.

Arthur Harvey—I think the mining laws are satisfactory as they are. It might be well that a man should be allowed to take 40 acres if he did not wish to take 80 acres, but 80 acres at $2 an acre is a very small thing. The government might adopt a liberal policy with prospectors—say the prospector to pay a deposit of 50 cents an acre and do a certain work each a year. I would put the price of mineral land at $5 an acre and spend the money on mineral development. As a general thing I think the prospector is fairly rewarded for his work.

Iron locations.

C. J. Pusey—I have no suggestion to make in regard to any changes in the mining laws. I believe, however, that the iron locations should not be treated as those of the precious metals; it would not be wise to limit them to a small area.

Prospectors' rights.

W. H. Wylie—The government should encourage prospectors; if they find any mineral they should be able to secure it without having to buy the property. As it is now the properties are often jumped before they can secure their finds. My idea is that they should be allowed to stake out their claims.

Protection of forests against fire.

E. W. Rathbun—I think the Ontario government is doing all possible to prevent waste of timber by fire, by not allowing settlers to go on land that is not fit for settlement. It is good policy, and to the interest of the lumberman, to have good settlers on land that is fitted for farming. I think the government is doing its best to husband the timber and prevent fires.

Staking out claims.

Miners' regulations.

Prospectors should be encouraged.

H. C. Jones—I reside in Toronto, but have had experience in gold and silver mining in California. I do not consider that our laws are calculated to promote the development of mining. In California and Nevada it is not necessary for the prospector to go to the expense of getting a surveyor; he can stake out his own claim. I think we should have laws similar to those of the United States. I think the law here tends to prevent prospectors getting a fair chance. As a general rule they cannot pay for the land. In California if the explorers had to pay $2 an acre and take up so much land they would not have done anything. I would propose to allow the miners of a district to meet together and make such laws as they deemed proper as to the size of the claim and so forth, and that the custom of the miners should become the law of the state. Large blocks of land should not be sold; 200 feet on the vein is sufficient for a gold mine. If large blocks are sold the sale should be accompanied with conditions as to work. I think the prospector should not have to pay anything; it is enough for him to go into the bush and work. A claim should not be more shan 300 feet on the lode, but a man might purchase as much as he liked afterward providing a certain quantity of work was done on each claim.

Special terms for prospectors.

Size of locations.

J. F. Latimer—I think the prospector should be allowed to take up at least one location without paying for it immediately. Or, if he chose, he should have the right to pay 10 cents an acre till he wished to take a title and pay for the land. I think the location should be about 80 acres. He should have the right to stake out his claim, numbering his stakes so that a survey could be made at a future time starting from stake No. 1. He should be allowed to hold that by paying 10 cents an acre each year till he was in a position to purchase it. I should say the 80 acres should be laid out as the government lays it out now. The sale of large blocks should not be allowed, except perhaps in the case of iron. I cannot say whether taking 80 acres would be more satisfactory than a location 1,500 by 600 feet on the vein. The advantage of making it 80 acres is that the country would not be so much cut up.

Lake Superior mining division.

The system of miners' licenses in practice.

E. B. Borron—The provincial legislature enacted in 1868 what was called the Gold and Silver Mining act. This measure was repealed the following year, and the General Mining act was substituted. Under this act the lieutenant-governor in council can declare any tract of country a mining division and appoint an inspector. The north shore of lake Superior from Slate island to Pigeon river and from the coast northward and westward to the height of land was declared a mining division, and called the lake Superior mining division, and on the 17th May I was appointed inspector. Under the terms of this act mineral lands might either be bought from the crown unconditionally or could be occupied and worked as mining claims under miners' licenses and subject to various conditions. As inspector I was to grant and renew miners' licenses on payment of a fee of $5; to keep a book called a register of mining licenses and another called a register of mining claims, the latter of which was to be open to inspection by any person on payment of a fee of 20 cents. I became *ex officio* justice of the peace, and was given such additional powers as would enable me to settle summarily all disputes between licensees, as to the existence or forfeiture of mining claims, the

extent of the boundaries thereof, the use of water, and generally to settle all difficulties between licensees which might arise under the act. Only some fifty or sixty miners' licenses were issued during the four years I was inspector, and very few mining claims were registered. Most of those who took out miners' licenses did so in order to gain time to survey and purchase the land. Thus the act, which was really an experiment, proved a failure, and in 1873 I resigned. No other inspector having been since appointed, these provisions of the mining act are practically inoperative. I consider the mining laws of Ontario as liberal as those of any other civilised country. There are classes of men specially interested in mining, and it is in the power of the government to do something to the benefit and advantage of each. First we have the explorers, who however important are generally poor. These men should have every reasonable facility afforded them for carrying on their explorations. They should be able to obtain good maps showing as much as is known of the geology of the country, at a cheap rate. I have already pointed out that the system under which miners' licenses were issued was a failure. It remains, therefore, for the government to make the regulations under which the explorer can buy or otherwise secure the land on which he discovers minerals of value as liberal as possible. I am of opinion that the provisions in the act of 1869 will admit of some amendment favorable to the poorer class of prospectors. I think the explorers should be allowed to buy locations of 40 acres in the surveyed or unsurveyed territory, instead of a minimum of 80 acres as at present. The price of land in the unsurveyed district should be less than in the surveyed, and if the location be not more than 40 acres he should be allowed to stake it out himself, as was the case in regard of mining claims. The explorers should not be required to pay the whole price for the land cash down on application, but should be allowed to pay one-fourth or one-fifth only of the purchase money, and given the privilege of throwing it up altogether at the end of a year if the vein when tested proved worthless. The explorer should be able also to enter and purchase his location at the nearest crown land office. To prevent the evils arising from the acquisition of large tracts of land for the purpose of speculation I suggested to the commissioner of crown lands over twenty years ago the desirability of imposing a ground rent of not less than ten cents an acre on all mining locations sold after that date. This would have hardly been felt when included in the working expenses of a mine, and, as proved by the large number of locations which have been abandoned as the result of a tax of two cents an acre, it would have proved a remedy. I am inclined to think that with the exception of a very small sum, say 25 cents an acre on application, it would be better if the equivalent required for grants of mineral lands were in the form of a ground rent, perpetual or for 99 years as deemed best. I would not consider 25 cents an acre per annum at all too much. It would not in my opinion discourage either exploration or legitimate mining operations, and would yield a permanent revenue to the province. It is of some importance that explorers and others should be able to get specimens assayed with as little delay and at as reasonable a charge as possible, but I do not see that the government can do anything in the matter. If the science masters in the collegiate and high schools in or near the mineral districts were selected with reference to their competence in this branch of chemistry they might be able to make assays of the more common ores at a reasonable charge, and thus meet the wants of the explorers to that extent. Generally the explorer sells his discovery to the capitalist. In the sale he is usually assisted by middlemen, whom he is obliged to employ or take in as partners. These middlemen are for the most part shrewd and keen, but not always honest and honorable men. Against the danger of being beguiled into paying an extravagant price for a poor location or mine the government can do nothing. As under any circumstances other than those which may and I believe would follow from commercial union, the amount of capital available for the development of our mineral resources will be very limited. It is of the greatest consequence that this capital shall be invested in the most promising mines. Every failure tends to frighten away capitalists, while every rich dividend paying mine attracts them.

Explorers.

Small locations and terms of sale to explorers

Ground rents.

Assaying of specimens.

Middlemen.

Best encouragement of capital.

H. P. McIntosh—It would be a great mistake to change the mining laws so as to allow parties to stake claims, as it would be a fruitful source of annoying litigation. The government should not sell lands in less amounts than it now does, and there should be no reservation of minerals. The good title now received from the government is the one thing favorable to those who risk their money in mining enterprises, and any change is likely to be in the nature of complications.

Staking claims.

Good title.

Capital needs to be encouraged.

C. S. Morris—Under the present law I think the prospector is protected in all his rights, and I have yet to learn of an instance where he has been wronged. Capital is very hard to get to develop mining properties, and I think it is most important to do all possible to induce investment. All the prospector can do is to find the mineral ; he stops there ; it is capital that has to take the risk and go on and develop. I have had considerable experience of the difficulty of raising money to develop property. I have made a good many sales in the States. In the case of a silver property I sold a company was organised with a capital of $2,000 000. That property has been worked to some extent. I do not see any necessity for any change in the mining laws ; restriction of areas and compulsory work would lead to evasion. The opening up of roads in the back country would be a great boon. I also think that it might be well to simplify the Joint Stock act as regards mining companies.

German mining laws.

Frederick Miller—In regard to the mining laws, I think those of Germany are the best. By obtaining permission from the government a man can go on any person's property, and in case he cannot agree as to the amount to be paid with the proprietor the government steps in and the matter is settled by arbitration. In my experience of fifteen years I never had any trouble with the owners; they were always glad to make an arrangement. The owner is allowed a royalty or interest, and the government retains two per cent. in kind. In the sale of the land the minerals were originally reserved in Germany.

Prospectors on private lands.

W. H. L. Gordon—We do all we can to encourage prospectors on the Canadian Land Emigration Co.'s property. We tell them the price of the land beforehand and they can go on and explore. If they find anything they will not have any more to pay, and if they find nothing they will not have anything to pay us. I have no doubt the company would be willing to give prospectors a half interest in anything they found. We would, of course, charge more for a phosphate lot near the railway than for one twelve or fifteen miles back. I think it would be about right to allow a half interest in any find, but the prospector should be compelled to work it. I am of course stating my own view, and do not wish to be understood as speaking for the company. I think it would be worth while to give a half interest to get our minerals developed, but I do not consider that the government should give the prospector the right to go on private land without compensation.

SECTION V.

ON THE SMELTING OF ORES OF ECONOMIC MINERALS IN ONTARIO.

The parable of the wicked and slothful servant who hid his lord's money in the earth instead of putting it to the bankers seems to find a life-like illustration in the record of the mining and metallurgical industries of Ontario. The preceding Sections of this report are replete with evidence of the large and varied mineral wealth of the province, as also of the unsavory fact that, however much is hidden in the earth, little has been taken out or "put to the bankers." Still less savory is the fact that in the smelting of economic minerals we have to show for the most part only a record of failures. Of the eight or nine ventures made up to the present time, five of which were iron furnaces, only one survives, the furnace for reducing copper and nickel ores at Sudbury, and it has been in blast only a few months ; the others are in ruins. The slothful servant in the parable had his one unused talent taken from him and given to the faithful servant who used his five talents in trade to gain another five. That appears to be the lesson of all history, and the moral is so plain that the blind may read it. √ A record of failures.

IRON SMELTING.

The first iron furnace in this province was erected about the year 1800 in the northern part of the township of Lansdowne, in the county of Leeds, at the falls of the Gananoque river. The ore used was of inferior quality and had to be drawn a considerable distance, and after two years' trial the enterprise was abandoned. An attempt was made to cast such hollow-ware as pots and kettles for the use of settlers, but that also proved to be a complete failure.* A furnace in Leeds county.

Thirteen years later one John Mason, an Englishman, started to build the second blast furnace, his object being to smelt the bog ores in the county of Norfolk. The site chosen was on the shore of lake Erie, at the mouth of a small living stream known as Potter's creek in the township of Charlotteville. The creek was large enough to furnish all the power required to drive the machinery, and the lake was convenient for shipping the product to any ports along its shore. But Mr. Mason had many difficulties to meet and overcome. Neither the necessary materials nor the skilled labor were obtainable, except at large cost, and the plant when completed was rude and primitive.† The Normandale furnace.

*The furnace was erected by a company composed of Ephraim Jones, Daniel Sherwood, Samuel Barlow and Wallace Sutherland, and the location was known as Furnace Falls, now Lyndhurst. In the Geological Survey report for the year 1851-2 Alexander Murray states that the ore used was a "scaly red iron ore," and was obtained on lot 25 of the 10th concession of Bastard, "but the quantity in the locality worked was not sufficient to give a profitable result."

†"I want five or six pieces of cast iron, each 30 cwt.," he wrote to Robert Gourlay in 1817. "These will come to an enormous expense. I intended to ask government to give or lend me six disabled cannon for this. I asked government to pay the passage of five or six families from England to work in the furnace. This could not be granted, and therefore I

Manufacture of iron from bog ore.

Nature of the usiness.

And misfortune followed to the end, for the furnace had only made a few tons of pig iron when the inner lining gave way and the enterprise was given up in despair. Mr. Mason soon afterward sickened and died. The property remained going to decay until 1820, when it was bought by the late Joseph VanNorman. In March of the following year Mr. VanNorman formed a partnership with Messrs. Hiram Capron and George Tilson, and in 1822, after an expenditure of $8,000, the furnace was blown in. The ore supply was found within a range of twelve miles and was drawn to the furnace with waggon teams, the daily consumption being about nine tons, which yielded an average of three tons of pig iron of excellent quality. The furnace was in blast eight or nine months each year, producing 700 or 800 tons of iron with a consumption of charcoal fuel equal to 4,000 cords of hardwood. There was however no sale for pig iron, and the whole of it was made into various kinds of castings, shipped to ports along the lake shore from Fort Erie to Amherstburg, and taken into the interior by teams to find a retail market.* In this way the new settler was furnished with sugar kettles and potash kettles—the latter for manufacturing the only article of export for which payment was received in cash. There was little money in the country in those days, and business was carried on by the exchange of commodities. What the farmers of the district had to sell was brought to the furnace and exchanged for the wares or due-bills of the company. Due-bills for iron were used as a kind of circulating medium over a large section of the province, and at one time the books of the establishment showed an amount of over $30,000 outstanding. When the home market became overstocked the firm exported its manufactures to Buffalo, and one ship-load of stoves and other castings was sent to Chicago. Joseph VanNorman was the managing partner of the company, and gave the name of Normandale to the locality where the business was carried on. After five or six years he bought out the interest of Messrs. Capron and Tilson and took in his brother Benjamin, who retired a few years afterward; and from that time until the furnace was shut down in 1847, owing to the scarcity of ore and fuel, the business was conducted in the name of J. VanNorman & Son. The enterprise appears to have been sagaciously managed from first to last, and Mr. VanNorman made a fortune which he lost elsewhere.†

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would not ask for the cannon. Another thing against me is, that there is not a man in the country that I know of capable of working in the furnace. But the greatest difficulty I have to overcome is iron-men, as we call them, are the very worst sort of men to manage, colliers not excepted. Not one of a hundred of them but will take every advantage of his master in his power. If I have just the number of hands for the work, every one of them will know that I cannot do without every one of them; therefore every one of them will be my master."—Statistical Account of Upper Canada, vol. I, p. 325.

*What old resident of the lake Erie counties does not remember the VanNorman stove, that warmed the country stores and bar-rooms, and school houses and township halls of forty or fifty years ago? And the plate of the VanNorman stove was, saving in finish, such as one never sees in the stove-plate of to-day.

†G. R. VanNorman, Q.C., of Brantford, who several years ago furnished the writer with a memorandum prepared by his father concerning his operations at Normandale, Marmora and Houghton, gave also some interesting information relative to an economic invention used at an early period in the Normandale works. It is not claimed that Mr. VanNorman was the original inventor of the hot-air blast, which was patented by J. B. Neilson of Glasgow in 1828, but that he used and applied it without a knowlege of Neilson's invention. "I think there is reason for limiting his claim to this extent," his son says, "he invented an oven for the double purpose of heating the blast and roasting the ore." Bog iron ore contains a large amount of moisture, and unless it is dried or roasted before being put into the furnace an

A blast furnace was erected on the Crow river, township of Marmora, about the year 1820 by Mr. Hayes, to treat the magnetic ores of what is known as the Big Ore bed at Blairton on Crow lake. Little seems to be known of this enterprise except that Mr. Hayes lost heavily by it, and that the property passed into the hands of Hon. Peter McGill of Montreal, the principal creditor. In 1828 the legislature appears to have been asked by Mr. McGill for aid to carry on the works in the shape of a loan of £10,000, and in 1831, upon the petition of Messrs. Hetherington, McGill and Manahan, an act was passed to incorporate the Marmora Iron Foundry. In 1839 commissioners were appointed by the government to enquire into the probable cost of transferring the penitentiary from Kingston to Marmora, and the terms upon which the Marmora iron works could be purchased, the object evidently being to utilise the labor of convicts in the mining and smelting industry. But nothing came of the efforts to interest the government in the company's affairs, and the business was carried on at a heavy loss. Mr. VanNorman was induced to purchase the property in 1847 for the sum of $21,000, after closing down the furnace and works at Normandale. In the fall of 1847 he moved to Marmora, and after expending a large sum in fitting up the furnaces, putting in machinery, ovens and blowing apparatus, erecting and repairing buildings, cutting cordwood and making charcoal for fuel, he got the furnace started in the summer of 1848. But the amount of iron produced from a given quantity of fuel was a sad disappointment, and nothing but disappointment and loss attended every effort. After the iron was made it had to be carted a distance of thirty-two miles to Belleville, over rocks and log-crossings and roads so rugged that waggons were constantly breaking, and the shoes of the horses were pulled off between the logs and stones. The obstacles were such that it was found impossible to bear up under them, and a new route was tried. A road nine miles long was built from the ore bed on Crow lake to Healy's falls on the Trent river; a steamer on the river carried the pig iron to Rice lake, and thence it was carted twelve miles to the dock at Cobourg.

The Marmora furnace.

A succession of failures.

VanNorman's venture.

extra quantity of fuel is required to smelt it. By constructing a set of brick ovens or chambers at the level of the charging door and connecting them with the shaft by pipes Mr. VanNorman was enabled to roast the ore by utilising the waste gas and heat of the furnace. Openings in the sides of the oven admitted atmospheric air, which, coming in contact with the gas, produced combustion, and the ore in the chamber was raised to a white heat, the hot air blast of the furnace being fed at the same time through pipes connected with the roasting chamber. In this way the ore and the blast were both heated without the use of any wood, coal or other fuel than the escaping gas, which would have passed otherwise out of the chimney to be lost for any useful purpose. "It was this invention in its entirety," G. R. VanNorman says, "that my father claimed and sought to have patented in the United States, and in which he failed, not because it was not new and useful, but by reason of his being advised by his agent at Washington to pay not the $500 required from a British subject, which he was at that time, but the $25 fee payable by an American citizen, he having been born in the United States. The oven was the invention he claimed; the hot air was only part of the invention, and it is very probable that hot air may have been used in blast furnaces prior to the invention of the oven, although not known to my father at that time. The oven was also used in the forge for heating blooms and iron bars so that they could be hammered into the requisite sizes." Phillips, in his Elements of Metallurgy, says that shortly after the application of hot blast to iron-making various attempts were made to employ the waste heat escaping from the throat of the furnace, and now the employment of waste gases has become almost universal in all iron-producing districts. The credit of having first attempted to utilise the furnace gases is given to Aubertot of France, who according to the Encyclopædia Britannica constructed a kiln for that purpose in 1811 (Sir Lowthian Bell says 1814); but it was not until George Parry of Ebbw Vale invented the cup and cone arrangement about 1850 that the utilising of furnace gases became general. In 1845 J. P. Budd took out a patent in England to use waste gases for heating the blast, but Mr. VanNorman's stove appears to have been an earlier invention.

The cost of carriage by this route was cheaper than the other, and the pig iron sold readily at $30 to $35 per ton. But about this time the St. Lawrence canals were completed and foreign pig iron began to be brought up and sold at Belleville and Cobourg at $16 per ton. This circumstance alone settled the question of producing charcoal iron in the province except at a ruinous loss to those engaged in the business, and Mr. VanNorman was compelled to close his works with the loss of everything. A few days before leaving Marmora he received a letter from the Hon. Peter McGill expressing regret at his failure and enclosing him a cheque for £100.* In Mr. VanNorman's memorandum it is stated that after him came the Marmora Iron Foundry company whose losses were not far from £20,000, and that next came an English company whose losses were said to be not less than £75,000. The Marmora Iron Works company was formed in Belleville, and according to a statement of one of its members the quantity of pig iron produced by one of the two furnaces was five tons per day of very superior quality, and it was found after a test run that the probable cost of manufacture in a blast of longer duration would not exceed £3 or £3 5s. ($12 or $13) per ton. "Excellent as is the cast iron made from this ore, it is still more suitable for bar iron, the toughness and ductility of that which has been made there giving it a preference to the best Swedish iron."†

Marmora Iron Works company.

The English company began operations in 1856, when extensive repairs were again made, and with worse results than had attended any of the previous ventures, apparently because the manager did not understand how to treat the ore. The furnace was again in blast for a short time under the charge of Mr. Bentley, and in the report of the Geological Survey for 1866 an account of the work done is given by Mr. Thomas Macfarlane, who was then a member of the staff, from information supplied by Mr. Bentley. "The furnace then ran forty days in all," Mr. Macfarlane wrote, "and was working well and constantly increasing in yield when orders were given to blow out because funds to pay the workmen were not forthcoming. Until the fourteenth day a hot blast was employed, but the heating apparatus then broke down and during the remaining twenty-six days a cold blast was used. The charge consisted of 400 lb. ore and 23 lb. limestone. The fuel used to each charge was sixteen bushels of charcoal. While the hot blast was being used fifty charges

An experimental run.

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*Joseph VanNorman's memorandum.

†"The iron mines were worked some years ago, and large sums were expended without any beneficial result. This however is not surprising, as although the distance of the works from the front is not so great as to prove in future any great bar to their successful occupation, the means of communication have hitherto been so little improved that during certain portions of the year the settlers in the back townships were almost debarred from intercourse with the front, roads existed merely in name and the expense of carriage of a heavy article like iron was great. This however is not the only reason why these mines have been unproductive, or productive only of loss to those engaged in the manufacture. The parties who have had charge of the works have been constantly behind the age they lived in. When through the agency of the hot blast and new methods of treating the ore the cost of manufacturing cast iron had been materially reduced in Britain, the old mode of smelting by means of the cold blast was attempted here, as well as the manufacture of bar iron without the aid of any other machinery than the hammer, the anvil and the bellows. Under such circumstances it is not surprising that the proprietors of the works could not compete with importers, or British iron masters who carried on their operations by means of the most improved machinery, with large capital and coal at an almost nominal price. The attempt however was persevered in manfully, till many thousands of pounds were sunk by the proprietors. This however could not last, and the works were closed."—Smith's Canada, vol. , pp. 246-7 (1851).

were smelted per diem, and five tons of iron produced. With cold air the ore consumed and the iron produced amounted only to three-fifths of these quantities. To ascertain the actual cost of producing the iron was more difficult as the general expenses of the establishment were enormous. Assuming these to amount to $2 per ton of product, the following may be considered as the actual cost of one day's running during the last trial of the hot blast at Marmora:

Cost of production.

Items of cost.	$
10 tons of ore at $2	20 00
800 bushels of charcoal	48 00
1 furnace man	2 50
8 laborers	8 00
Repairs, wear and tear, etc	4 00
General expenses	10 00
Cartage to Belleville of 5 tons of iron	20 00
Total cost of 5 tons pig iron	112 50

Equal to $22.50 per ton. Now as the pig iron probably realised $27 per ton in Belleville, a profit of $4.50 per ton would appear to have been made."* The cost of production at the furnace would be $18.50, and this includes the high allowance of nearly $3 per ton for repairs, wear and tear and general expenses. But it must be borne in mind that the output was only five tons per day. The last attempt to smelt ore at Marmora was made about the year 1875, when an experiment was tried with petroleum as fuel.

The Madoc furnace.

A charcoal blast furnace for smelting magnetic iron ore was erected at the village of Madoc, county of Hastings, in 1836 or 1837 and was worked with varying success for eight or nine years. The manager was the late Mr. Uriah Seymour, formerly of New York state, and some account of his smelting and foundry operations at Madoc is given in the evidence of his son, Mr. F. E. Seymour. A company of which Uriah Seymour was an active partner operated a furnace in Wayne county, and the testing of some sample lots of ore taken from what is known as the Seymour mine, on lot 11, concession 5 in the township of Madoc, led to the erection of the local furnace. An interesting account of this enterprise has been preserved in the Geological Survey report of 1866, the writer, Mr. Macfarlane, having procured the facts from the elder Mr. Seymour. "The first experiment with the ore," Mr. Macfarlane says, "was made by Mr. Seymour in the furnace owned by him and his partners at Wolcott, Wayne county, New York. This was in the winter of 1835. Three and a half tons were treated, and it was found to improve the quality of the iron previously made there. First one-fourth and then one-half of the Canadian ore was used, and the iron produced became softer and stronger. Ultimately the Canadian ore alone was charged into the furnace, and a still better quality of iron was obtained. These results being considered satisfactory, Mr. Seymour erected a furnace at Madoc in 1837 and

Experiences with furnace material, flux and fuel.

* Geological Survey report, 1866, p. 108.

put it in blast. Limestone was used as a flux and three different blasts were started with different materials found in the neighborhood for hearthstones. In each of these three trials the hearthstone was rapidly cut out by the slag, the furnace became unworkable and was blown out, always at a great expense for repairing the furnace and for fuel in heating it up. Mr. Seymour, supposing the bad quality of the hearthstones to be the cause of these misfortunes, procured a new hearth from Rossie in New York of the material used in the furnaces there. The furnace was again started, but, by way of precaution, with a blast at only one tuyere. The same flux was used as formerly and the same slag was produced, cutting into the Rossie stone as much as it had ever done into the hearthstones previously used. It having been thus demonstrated that the former hearthstones were not at fault, since even the Rossie stone could not withstand the slag, Mr. Seymour decided to alter the flux, substituting for the limestone a sandy clay. This was done, the blast was stopped at the damaged tuyere, and introduced at the one which had been kept unused. Very soon the character of the slag changed. It became mild, did not cut into the hearthstone, and kept fluid and in motion long after it left the furnace. The iron was of excellent quality, but at this time the stock of charcoal became exhausted, it being impossible to procure charcoal burners to keep up the supply. Reduced to extremity, Mr. Seymour caused cordwood to be sawn up into lengths of two feet and used instead of charcoal. For seventy-five days he continued to work his furnace with the same fuel and with only one tuyere, producing a good slag and excellent iron to the extent of one ton daily. About eighty tons were produced in all during the blast and cast into stoves, potash kettles, etc., besides a small quantity of pig iron. The latter found a ready sale in Belleville at $27 per ton, and was considered of first-rate quality for machinery. Encouraged by his success in smelting with wood, Mr. Seymour repaired the furnace and started it again with wood alone as fuel and with the two tuyeres at work. From two to two and a half tons of iron were produced daily, but it was of an inferior quality; the castings made with it cracked in cooling. Mr. Seymour was led to suspect that this was caused by the wood descending too quickly and insufficiently charred into the furnace. That this did affect the quality of the iron was proved by stopping one of the tuyeres. The daily produce sank to one and a quarter tons, but the good quality of the iron was restored and the furnace kept in blast three months. The exact cost of the operation I could not ascertain, but Mr. Seymour assured me that according to his books this blast contributed somewhat to improve the financial position of the concern. The daily product of iron was however too small and smelting with charcoal was again resumed, in the midst of which Mr. Seymour's partner was killed by an explosion in the mine. The difficulty of settling with his heirs became superadded to the financial difficulties of the concern, and Mr. Seymour's means having become exhausted he was obliged to suspend smelting operations. Among the facts demonstrated by his experience, not the least interesting was the producing of cast iron of excellent quality in a blast furnace with wood alone as fuel. Mr. Seymour entertains the opinion, and surely his experience justifies him in so doing, that were a

Results with wood fuel

Cost of production.

furnace specially built for the purpose, and so high as to allow the materials fifty hours to descend, wood could be used as fuel and five tons of iron produced daily. His estimate of the cost of doing this is as follows :

Items of cost.	$
15 cords of wood at $1	15 00
10 tons of iron ore at $1.50	15 00
1½ tons loam.	1 50
Crushing ore at 10 cents	1 00
Labor, 2 top-men	4 00
Labor, 2 furnace-men	4 00
Labor, 1 gutter-man	1 50
Labor, 1 overseer	5 00
Wear and tear, etc	5 00
General expenses	8 00
Total cost of 5 tons pig iron	60 00

This is equal to $12 per ton of iron produced, and if the freight to Belleville be added the total cost is $16 per ton. With cast iron at $26, the profit would be $10 per ton."* Mr. Macfarlane further states that on general grounds it is reasonable to suppose that when properly conducted the same success would attend the iron manufacture in Madoc and Marmora as has attended it in other countries where similar conditions exist. "In Sweden and Norway, as in Canada," he says, "the ores are generally magnetic, the fuel charcoal, the motive power water, the means of transport and communication imperfect ; labor is certainly cheaper, but the ores are less rich—33 per cent. being the average in Norway. The same conditions as to ore, fuel, etc., obtain in New York, where the smelting of iron ores seems to be very successful ; and if care be taken to employ the same skill, and with due care and judgment the same apparatus and processes which are there applied with perhaps slight modifications, iron would doubtless be as successfully made in Canada as in New York. The protective duty in the latter country is to a great extent balanced by the higher prices for labor and fuel."† The failure of Mr. Seymour's venture, according to the accounts of Mr. Macfarlane and of his son, Mr. F. E. Seymour, does not appear to have been due to the quality of the ore, but rather to the primitive methods employed and the lack of sufficient capital where costly experiments had to be carried on with an ore the nature of which was not perfectly known. The use of loam instead of limestone for flux seems to have been attended with very satisfactory results, a knowledge of which may prove to be valuable in the future treatment of our dense magnetic ores.

The Houghton furnace.

After the failure of Mr. VanNorman at Marmora, already referred to, that pioneer iron-maker returned to his old home at Normandale. The Great Western railway was then under construction, and parties concerned in furnishing car-wheels for the railway company (Messrs. Fisher & McQuesten

* Thomas Macfarlane in the Geological Survey report, 1866, pp. 109-111.

† Geological Survey report, 1866, p. 111.

of Hamilton) experienced much difficulty in getting suitable iron for the purpose. The charcoal iron formerly made by Mr. VanNorman out of the bog ore was believed to possess the requisite qualities, especially the quality of chilling or hardening when cast on an iron surface, and a contract was made between the parties in which the founders agreed to take all the pig iron Mr. VanNorman could produce at $45 per ton, providing it was found to be suitable for car-wheels. As soon as the contract was signed Mr. VanNorman sent a prospector into the township of Houghton, in the western part of Norfolk, to ascertain if ore could be found there in sufficient quantities to warrant the building of a furnace. The report was very favorable, a blast furnace was erected, and smelting operations began in the fall of 1854. In the spring of 1855 a shipment of 400 tons was made, but not long after Mr. VanNorman was notified by the founders that the iron would not chill, and consequently could not be accepted under the terms of the contract. He visited Hamilton and saw to his surprise that the facts were as represented, and instead of getting $45 per ton for the iron he was obliged to sell it at $22. This was the period of the Crimean war, and business was booming in Canada as a consequence of the great demand for farm products, wheat selling at $2 per bushel. Labor cost nearly twice as much as in former years, horse feed and provisions of all kinds were high, and the iron cost more to produce than it was worth in the market. Under these circumstances the works at Houghton were abandoned, and Mr. VanNorman and his sons lost in this enterprise about $32,000. Between Marmora and Houghton all that had been made at Normandale was irretrievably lost, and Mr. VanNorman's career of over thirty-four years in the blast furnace business ended.*

VanNorman's second failure.

The last venture was made in 1882 by an American firm, Messrs. Parry & Mills, who erected a blast furnace on the Burnt river in the county of Haliburton, as stated in the evidence of Mr. Shortiss. They were unable to complete the works owing to insufficient capital. Every effort was made to borrow $10,000 upon the security of the property, Mr. Shortiss says, and although between $50,000 and $60,000 had been invested no financial assistance could be obtained and the enterprise failed. A report on the properties made to Parry & Mills by W. H. Merritt in 1883 shows that the furnace, charcoal and calcining kilns, saw-mill, etc., were well advanced towards completion, and he considered that when the plant and properties of the firm were placed at $65,000 they were valued at a reasonable and legitimate price. "With your exceptional advantages in wood limits," Mr. Merritt stated in his report, "enjoyed to no greater extent by no charcoal smelting works on the continent, excellent water power, proximity of flux, railroad facilities and short distance from market, I have not the slightest hesitation in saying that in my opinion, with ordinary good management, your enterprise will pay handsomely." Yet for lack of sufficient capital Messrs. Parry & Mills were unable to complete the works, and the money and labor they had expended became a total loss.

A Haliburton enterprise fails for lack of capital.

* Joseph Van Norman's memorandum.

LESSONS OF THE FAILURES.

This is a hapless record of failures ; but does it show that the pig iron industry has no future in Ontario? Has the industry had a fair trial under favoring conditions, and were the means taken and the methods pursued in all respects such as a successful iron man of the present day would commend or imitate? The Normandale works alone were successful, although not before the projector of them was ruined in getting experience.* Mr. VanNorman profited by John Mason's failure, and as the ore was not difficult to treat he was soon able to apply intelligent methods in his furnace. He was also fortunate in making such uses of the pig iron as the circumstances of the country most required at that time, and doubtless a second profit was made on the farm products which he took in exchange for his own wares. But the magnetic iron ores of Hastings and Peterborough required a different kind of treatment ; and although some knowledge of improved processes was gained by Mr. Seymour, Mr. VanNorman and others, it was not equal to the requirements of economic production with small capital and primitive methods in a region so inaccessible by reason of bad roads that the freight cost on supplies brought in from and products sent out to the nearest market town was $4 per ton. Failures have overtaken many other enterprises since then, in Michigan and elsewhere, from the operation of the same causes ; but they do not prove that success is not attainable under better conditions.† With modern plant, a practical and scientific knowledge of how to treat magnetic ores, adequate capital, facilities for cheap transportation and good business management, the manufacture of charcoal iron ought to be as successfully carried on in Ontario as in New York, Michigan or Wisconsin. It is possible also that the manufacture of coke iron and anthracite iron may be attempted, but until the trade relations between the United States and Canada are more free the freight charges are likely to be too heavy for these fuels to be brought in at a moderate cost. The rapid growth of the iron industry in Illinois, which increased from 78,455 net tons in 1878 to 579,307 in 1888, is mainly a result of the greater cheapness with which the raw materials of manufacture can be brought together under a condition of free inter-state commerce. Return cargoes make cheap freights.

Has pig iron a future in Ontario?

Failures elsewhere.

Free commerce essential to economic manufacture.

OUTSIDE SOURCES FOR SUPPLIES.

The trade tables appended to Section III show that Canada's yearly average of imports of pig iron for the seven years 1881-7 was 60,000 net tons, and it is computed that if to this quantity be added the equivalent of all other iron and steel goods imported and the production of our own furnaces for consumption the total pig iron requirement of the Dominion is about

Canada's yearly consumption of iron and iron products.

* "Those who begin iron works after me in this country," John Mason wrote to Robert Gourlay in 1817, "will start many thousand dollars ahead of me; everything they want except stone will be had here, the best method of working the ore will be known, and men will be learned to work it."

† The editor of the Charcoal Iron Workers' Journal, commenting on the failure of the Steel Company of Canada in 1885, said: "It is seldom that pioneers in iron manufacture in any region are successful, and almost every iron producing district in the United States has a graveyard of buried hopes and expectations." (Vol. VI, p. 326.) But the experience of Canada where $2,500,000 was spent in this one enterprise led him to believe that there must be a cause for it beyond the ordinary course of events.

275,000 tons yearly. The pig iron made in the country is an inappreciable quantity, and the province of Ontario does not produce a ton.* Our foundries and iron works are largely dependent upon outside sources for supplies, four-fifths of which are imported from Great Britain. The whole of the charcoal iron comes from the United States, chiefly from Michigan, Wisconsin, Connecticut, New York and Alabama, but it does not exceed 15,000 tons a year. Now as it does not appear certain at present that we could safely enter upon the smelting of iron ores with mineral fuel in Ontario, it is all the more important to consider the business outlook for smelting with charcoal fuel. Is the home consumption large enough to make a market for the production of one or more blast furnaces? In view of the cost of production and the market prices, is there a reasonable prospect for investment of the required capital? Is the demand for charcoal iron likely to continue and grow?

The outlook for charcoal pig iron.

CHARCOAL IRON AND ITS USES.

Owing to its purity, fine quality and strength charcoal iron is used largely in Canada and the United States for malleable castings, and chiefly for car wheels. In the manufacture of these wheels it is of the first importance to secure strength to resist the strains and shocks to which the body of the wheel is subject in travelling on the rails, and sufficient hardness in the tread and flange to stand the wear to which it is exposed. The latter property is given to the iron by the process of chilling, which is produced by making the tread and flange portion of the mould of cast iron. When the molten metal comes in contact with the iron section of the mould it receives a chill, the effect of which is to crystallise it to a greater or less depth if of the right brand. Upon some kinds of iron the chill-mould has no effect, whereas upon others the chill will extend one or two inches in depth. The very hard and brittle iron usually chills most, but the body of the wheel must be tough and strong, and capable of standing strains and blows of every description. Hard white iron chills easily and has a high tensile strength, but it is so brittle that it will not bend, and if exposed to a sudden shock it will break with a comparatively light strain. Then again iron may be too soft and flexible, and have so little strength that it will bend like a bar of lead. The iron which has the two qualities of tensile strength and flexibility combined in the highest degree is consequently the kind best suited for the body of the wheel, while for the tread and flange it must have the chilling

Car wheels and malleable castings.

Qualities of iron required for car wheels.

*Statement of the quantity of pig iron upon which the Dominion government has paid a bonus for each of the last six fiscal years, together with the amount so paid, as furnished by the treasury department at Ottawa:

Fiscal year.	Tons.	Bounty paid.
1883-84.	29,388.16	$44,089 91
1884-85.	25,769.13	38,654 91
1885-86.	26,179.196	39,269 56
1886-87.	39,717	59,576 00
1887-88.	22,209.61	33,314 41
1888-89.	24,822.42	37,233 62
Totals......... ...	168,085.516	$252,138 41

property.* Now the experience of railways in the United States and Canada is that the best iron for the purpose is that which is smelted with charcoal fuel, and in both countries little of any other kind is used. In this country we are largely dependent on the United States for our supply, and wholly so in Ontario. The furnaces at Three Rivers and Drummondville, in Quebec, produce 8,000 to 10,000 tons yearly, the greater part of which is used in Montreal, where there are two car wheel foundries. John McDougall & Co., who own and operate the Drummondville furnaces, use the whole of their own make of pig iron and import from the United States besides. They melt about 45 tons of metal per day, all charcoal pig. The Montreal Car Wheel Co. obtain their supplies of charcoal iron from lake Superior, Salisbury and other districts in the United States. The Salisbury iron costs about $38 per gross ton delivered at the works, and the lake Superior iron about $27. They use charcoal iron solely in the manufacture of car wheels, and run about 20 tons per day. The Grand Trunk works at Hamilton have used about 1,800 tons of charcoal iron annually for the past eight years, but it is expected that in the near future this quantity will be increased to 7,000 tons per annum. The iron is purchased in Michigan and Connecticut principally, and costs from $23 of the former to $34 of the latter per gross ton, exclusive of duty. The St. Thomas car wheel works when running to their full capacity use 25 to 30 tons of charcoal iron per day. Lake Superior iron costs, laid down and duty paid in that city, $26 per ton; Salisbury iron $38; and the Southern iron, made in Alabama and Tennessee, about $30. The difference in prices is due chiefly to difference in qualities. "A very important consideration in the making of any castings of charcoal iron," the manager of these works says, "is the re-using of old charcoal iron, such as scrap car wheels. Certain classes of iron when put into service never turn up again as scrap, at least not for a long time, for instance, iron pipe and general iron fittings. Car wheels when worn out are very little depreciated in weight, and are melted over again with the addition of new iron. There is no doubt," he goes on to say, "that charcoal iron could be made to good advantage in Canada, the only obstacle being the large amount of capital required for investment in a plant and the uncertainty of the prices of iron until a permanent protective policy is insured." The malleable iron works of Mr. W. H. Frost at Smith's Falls use 1,000 tons of charcoal iron per annum, brought in over the Canadian Pacific railway from northern Michigan. The price fluctuates two or three times during the year, ranging from $27 to $35 per ton laid down at Smith's Falls and duty paid, and Mr. Frost says it may touch as high as $45. Other malleable works in the province are located at Oshawa, Merrickville, Guelph and Hamilton, and they use about 2,500 tons of charcoal iron a year, at prices ranging according to the brand from $26 to $36 per ton, including freight and duty.

Our consumption of charcoal iron

Montreal.

Hamilton.

St. Thomas.

Smith's Falls.

Other malleable works.

* Sir Lowthian Bell found in America that cold blast charcoal iron was infinitely preferred to metal smelted with hot blast for chilled railway wheels, wrought iron or steel being rarely used under railway carriages. It was uniformly stated, he says, that the cold blast iron wheels take a deeper chill and wear much longer than those made from hot blast, the same charcoal and minerals being used in both cases.—Principles of the Manufacture of Iron and Steel, p. 152.

The total quantity of charcoal iron used is not large, but the statements of several leading foundrymen warrant the opinion that much more could find a market at a lower range of prices. Mr. Copp of Hamilton stated that his firm use the best brands of British pig, costing $23 per ton, and mix it with about one-third Londonderry as the latter cannot be used alone, being a slaggy iron. They do not use charcoal iron at all, but he thinks they ought to use it as it makes the most valuable castings. With one-third charcoal iron he believes they could use English and low grade Scotch iron costing $3.50 to $4 per ton less than the best brands, and turn out a strong fine plate. A much finer plate is made now than formerly, and they require the best iron that can be got. "If our machine men," Mr. Copp said, "used more charcoal iron in their castings they would be of a better class, and it would be better for the country. As soon as it is established that charcoal iron makes better work we will all be willing to pay more for it." Mr. Laidlaw, another Hamilton foundryman, also uses the best Scotch iron, costing $23 per ton, but thinks they could use charcoal iron mixed with the Scotch, and that it would strengthen and improve the castings.

Opinion of foundrymen on the value of charcoal iron for castings.

Mr. Massey of Toronto stated that the cost of Scotch and Londonderry irons ranges from $18 to $21 per ton, but in his shops they do not care to use more than a quarter or a third of the latter. Detroit charcoal iron costs $25 to $27 per ton freight and duty paid, Alabama iron $30 and the Salisbury $36. "If Canadian charcoal iron," he said, "could be produced for a little more than Scotch or Londonderry, no doubt we could use it for nearly every kind of iron we want to make. It makes a stronger and better casting, and it would be simply a question of the cost. For machinery castings we want the best iron, and the expense is what has kept us from using charcoal iron. I would take charcoal iron at $24 a ton rather than imported iron at $22; I would consider it would be $4 a ton more valuable. Charcoal iron at $4 a ton more would command the market for all strong castings; we could use 2,000 tons of it. . . The manufacturers of agricultural implements would use it, and if one used it and made better castings competition would compel the others to do likewise. The cheapest charcoal iron at present imported costs $28 a ton, and if the Canadian were less than that it would command the market for charcoal iron." Mr. Massey does not believe that a profit of $6 per ton is made on charcoal iron in Michigan, and thinks they would be well satisfied to make a profit of $3 per ton.

An agricultural implement manufacturer's testimony.

COST OF PRODUCTION.

The question of the cost of production is less easily determined than questions of demand or market price. It has been shown how much of pig iron is required for yearly consumption in Canada, either in the raw material or its equivalent in the finished article, and how much it costs when imported, with freight, duty and the profits of makers and dealers added. These facts are easily ascertained from public documents and business men. But the actual cost of production is a business secret of the furnace men which few of their number care to divulge, and without full and exact data it can only be ascertained approximately. Besides, the conditions are so variable that the results are hardly ever the same for any two furnaces. Even in the same

Cost of production is a business secret.

furnace the figures are never constant over a long period of time, being affected by the quality and cost of ores, fuel, flux and labor, as well as by the working state of the furnace itself. Nothing need here be said of how much cost depends on intelligent methods of treating the ore, improvements in furnace construction, or the possession of technical skill and business capacity in the manager; but obviously they are essential pre-requisites of successful and economic production.

Essential pre-requisites.

The data presented in the following pages relate for the most part to the manufacture of charcoal iron, and have been selected with the view of showing as nearly as may be the range of cost from lowest to highest. In some instances it has been possible to procure the quantities of raw material only, but even these are useful in making up a general estimate.

Charcoal iron.

The items of cost at the Marmora furnace given by Mr. Bentley, the manager, to Mr. Macfarlane* are based on a daily run of five tons, two tons of ore at $2 per ton and 160 bushels of charcoal at six cents per bushel to produce one ton of pig iron, labor $2.10 and other expenses $2.80 per ton—making the aggregate cost $18.50. The items of cost at the Madoc furnace, also obtained by Mr. Macfarlane from the manager of the works,† are based on the same daily run, with ore of the same richness, but with wood instead of charcoal for fuel. There the cost of ore and fuel was $3 each per ton of pig, flux 30 cents, labor (including the crushing of the ore) $3.10, and other expenses $2.60—making a total of $12 per ton. Following is a comparative statement of the cost of production per ton at those furnaces:

Marmora and Madoc furnace records.

Items of cost.	Marmora.	Madoc.
Ore	$4 00	$3 00
Fuel	9 60	3 00
Flux		30
Labor	2 10	3 10
Wear and tear	80	1 00
General expenses	2 00	1 60
Total	$18 50	$12 00

The difference in cost of fuel, it will be observed, is $6 per ton, which may be readily accounted for by the large quantity of charcoal consumed at Marmora and the low charge for wood at Madoc.

In July, 1883, Mr. W. H. Merritt of Toronto, mining engineer, made an estimate of the cost of producing iron at Kinmount for Messrs. Parry & Mills, after a careful survey of the region and an examination of their works at that time in course of erection. The furnace was 50 feet high, 9½ feet diameter at the bosh, and it was computed that its daily output of pig iron would range from 20 to 30 tons. It was to be supplied with ovens to heat the blast to 900° F. if necessary, with a blower capable of supplying a blast up to three or four pounds pressure; a Blake crusher was provided to break the ore, and the machinery was to be driven by two turbine wheels of

An estimate for the Kinmount furnace.

* See page 323. † See page 325.

50-h.p. each. Twenty charcoal kilns were to be built, of the ordinary bee-hive style, and it was assumed that the cost of wood delivered at the kilns would not exceed $1.50 per cord, or cost more than $2 per cord converted into charcoal—the wood producing at least 40 bushels at five cents per bushel, although Parry & Mills claimed that they could make it for less per cord. The cost in the estimate was however taken by Mr. Merritt at six cents per bushel. "As I allow 120 bushels to the ton of iron," he stated in the report, "it will be recognised that this is equivalent to $1.20 more to the ton of iron above what may be reasonably expected." As it was intended to use mixed ores from the Howland mine, the Madoc region and elsewhere, the average cost was placed at $3.06¼ per ton of 45 per cent. ore. Limestone of fine quality was obtainable half a mile from the furnace and could be quarried cheaply; and labor was reckoned at the rate of $2 for skilled and $1.25 to $1.50 for unskilled per day. Taking these liberal prices as a basis of calculation, Mr. Merritt made up the following estimate of cost of production:

Items of cost.	$
2¼ tons of ore at $3.06¼	6 89
120 bushels charcoal at 6c	7 20
Labor and repairs	3 00
Wear and tear	50
Limestone	50
Cost per ton of iron	18 09

This was for one furnace with a capacity of 20 to 30 tons per day. "I do not think the cost of manufacture will exceed the above," Mr. Merritt stated, "unless some unforeseen misfortunes are met with. It probably will not reach that amount, and the cost of manufacture will be considerably lessened if there were two furnaces, as one could then always be in blast." At that time Hanging Rock and Virginia hot blast charcoal iron was selling in Virginia and St. Louis at $23 to $25 per ton, when it was believed that the bottom had been reached. Quoting these figures, which were $15 to $17 less than the high prices of January, 1881, Mr. Merritt made the following observation on profits: "At present low selling prices, and at cost of manufacture mentioned above, the profit would be from $3 to $5 per ton, calculating on bringing all the ore from elsewhere; or $4 to $6 if one-half mixture of local ore and ore brought from Madoc; or from $6.17 to $8.17 profit per ton if all ore used was obtained in the vicinity. Added to this will be $1.50 per ton bonus granted by the government. At a reasonable price for iron $8.50 to $10.50 per ton profit may be expected when the furnace is working well under good management." At the prices quoted by foundrymen examined by the Commission the profits inclusive of the government bonus would range from $10.40 to $21.40 per ton, and Mr. Massey expressed the opinion that the iron makers would be satisfied with a profit of $3 per ton.

Profits.

A report on certain iron ores in Lanark county made in November, 1883, by Mr. John Birkinbine of Philadelphia, secretary of the United

States Association of Charcoal Iron Workers and editor of their journal, was put in evidence by Mr. W. H. Wylie of Carleton Place. This report was made to Messrs. Wylie and Hall after an examination of properties in the townships of Darling and Lavant, with a view to the suitability of the locality for the establishment of a charcoal smelting furnace, and it embraced estimates of the cost of making pig iron from the ore. The ores examined were of the class of rich magnetites, those analysed showing about 66 per cent. of metallic iron; but in making his estimate Mr. Birkinbine calculated on an average of 55 per cent. ores, and the cost of mining at $1.60 per ton. "As wood is abundant and cheap," he stated, "you need have no fear as to fuel supply, and the character of the timber growth will make charcoal of the best quality. In many parts of the United States, where wood is by no means as plentiful nor of as good quality as in Lanark and adjacent counties, charcoal is made in meilers in the woods and delivered to iron works at six cents per bushel. When kilns are used a lower price still is often obtained; and if retorts are employed a further reduction in cost is possible, even if the gaseous products are not utilised. To illustrate: Our iron works have a battery of kilns located in wood very similar to that adjacent to locations examined, and a responsible party contracted to cut the wood, haul it to kilns, carbonise it, and deliver the charcoal in cars at four cents per bushel." In making his estimate however Mr. Birkinbine put the cost at five cents per bushel of 20 lb., which he considered would be ample for a number of years; and allowing for a possible refractory character of ore and contingencies of operation, an average consumption of 110 bushels for each ton of pig iron.* With these allowances the following estimate was given as ample to cover the expenses of producing one ton of pig iron, with a modern plant and appliances:

Estimates for a projected furnace in Lanark county.

Items of cost.	$
1.8 tons of 55% ore at furnace	3.60
0.3 ton of flux	45
110 bushels charcoal	5.50
Labor making iron	2.00
Repairs and supplies	50
Interest and superintendence	80
†Total cost per ton of iron	12.85

To produce 3,000 bushels of charcoal per day would require a plant of kilns to cost about $12,000, and to make the same quantity in retorts

Capital for land plant, etc.

* Charcoal pig iron, Mr. B. stated in his report, has been made with from 70 to 80 bushels of charcoal.

†In commenting on this estimate Mr. Birkinbine said: "Low grades of English pig iron now command nearly $20 per ton in Montreal; you could therefore probably deliver first class charcoal iron at the same point for $20 per ton and have a good profit. It is not to be presumed that those now supplying Canada with pig iron will fail to contest for the market with home production, but with a duty and bonus representing $3.50 per ton of product I see no reason why Canadian pig iron should not be able to largely or entirely displace that now imported." The bonus and duty represents now $5.50 per short ton.

would require an outlay of $25,000. Mr. Birkinbine gave the following estimate of capital required to acquire land, develop mines and smelt the ore:

Items of cost.	$
Mineral and timber land, say	10,000
Developing and equipping mines	30,000
Blast furnace	50,000
Tram roads, say	10,000
Dwellings, store, etc.	20,000
Charcoal plant, if retorts are used	25,000
Incidentals	5,000
Working capital	50,000
Total	200,000

The item of cost of land, it was explained, was not intended as a valuation of any particular property, but simply to show that the cost of land was not overlooked, and the estimate for buildings was made on the assumption that a company would wish to erect its own houses, office, store, etc. "To earn ten per cent. on this amount ($200,000) with an average output of 30 tons per day, say 9,000 per year, would require a profit of about $2.25 per ton of pig iron made"; so reported Mr. Birkinbine.

Estimate for a furnace at the Belmont mine.

Mr. Ledyard stated in his evidence that he had received an estimate from Mr. J. B. Witherow, a furnace builder of Pittsburg, Pa., for the manufacture of charcoal pig iron at the old Belmont mine at an actual cost of less than $10 per ton. He estimated the necessary capital at $150,000, the plant of which would include a Clapp-Griffiths converter capable of producing steel at $14 per ton, charcoal being reckoned at six cents per bushel. "We could deliver the ore at Toronto," Mr. Ledyard said, "supposing the company to own the mines, at $2.25 per ton—$1.50 to mine it and 75 cents for freight. If the furnace proprietors did not own the mines, then 50 cents per ton would be a fair royalty. In Chicago good Bessemer ore is $5.25 to $5.75; they use Connellsville coke, and I think it could be delivered here a little cheaper if there were no duty. With the fuel as cheap and the ore at half price, we should stand a good chance if we had the same market."

Estimates made by practical men.

Three several estimates of cost of production are presented in the evidence of Mr. C. J. Pusey, himself a practical iron maker—the proposed furnace to be located in the township of Snowdon, in Haliburton, and to use ores taken from mines owned by Mr. Pusey's company. The first of these estimates was made in 1881 by Messrs. Taws and Hartman of Philadelphia

Cold-blast furnace.

for a cold blast furnace of 100 tons capacity per week, in which it was proposed to use ores of the Howland, Imperial and New York mines, equal parts

of each, giving a mixture of 59 per cent iron. Their estimate of the cost of a ton of iron is as follows :

Items of cost.	$
4,000 lb. ore at $1 per ton	1.80
2,520 lb. (140 bushels) charcoal at 6 cents per bushel	8.40
177 lb. limestone	10
Labor, office expenses and superintendent's salary	2.50
Repairs and taxes	1.00
Cost of one ton of iron	13.80

Their estimate of the cost of the furnace, forty feet high and eight feet bosh, with hoist, tackle, cast-house, blowing engine and pipes complete, was $36,000 and of twenty charcoal kilns $10,000, each cord of wood to cost $1.30 at the kilns and to produce 45 bushels of charcoal.

The second estimate was prepared by Mr. J. P. Witherow of Pittsburg in 1884, and agrees with the one given by that gentleman to Mr. Ledyard. It was for a hot blast furnace of 60 tons daily capacity, and was based on prices of material and analyses of ores of the Howland and Imperial mines furnished by Mr. Pusey. Following are the details : Hot-blast 60-ton furnace.

Items of cost.	
2 tons ore (⅔ Howland and ⅓ Imperial)	2.33
80 bushels charcoal at 5 cents	4.00
⅓ ton limestone	25
Labor	2.00
Salaries and incidental expenses	50
Cost of one ton of iron	9.08

The third estimate was prepared by Mr. Pusey himself for a hot blast furnace of 30 tons daily capacity, to be erected at the Imperial mine and to use equal quantities of Howland and Imperial ores. The ore of the latter mine, Mr. Pusey stated, is too poor to ship, and he therefore proposes to utilise it on the ground. His figures are : furnace.

Items of cost.	$
5,600 lb. ore*	2.31
200 lb. limestone	15
1,800 lb. (100 bushels) charcoal at 5½ cents per bushel	5.50
Labor	2.50
Repairs, taxes, etc.	1.00
Cost of one ton of iron	11.46

* The larger quantity of ore in this estimate is explained by Mr. Pusey's statement of the lean character of the Imperial ore, which is too poor to ship.

One-half of the product of this furnace, Mr. Pusey stated, ought to be good enough for wheel iron or malleable castings, while the remainder would be suitable for foundry or milling purposes. Anthracite and coke iron could not, he said, be made for less than $14 or $15 per ton, and the market averages $18 per ton; while with charcoal fuel they could make it for $3 or $4 less, and get a better market for the product.

A Michigan furnace man's estimate.

The evidence of Mr. Shortiss of Toronto supplies an estimate of the cost of producing iron at Snowdon, given in 1885 by Mr. McCorquodale, superintendent of the Jackson Iron Co.'s furnace in Delta county, Michigan. It is based on the use of 55 per cent ore and hardwood charcoal, and is as follows:

Items of cost.	$
2 tons of ore at $2.50	5.00
100 bushels charcoal at 5 cents	5.00
Limestone	25
Labor and expenses	1.67
Cost of one ton of iron	11.92

The Jackson Iron Co.'s furnace.

Mr. McCorquodale was certain that Snowdon ore could be delivered at the furnace at $2.50 per ton, while at his own furnace the cost was $4.84 per ton; and he stated that they were able to make charcoal at 5 cents per bushel and haul the wood from three to four miles. "It is the long haul from the most distant kilns," he added, "that runs the price up to seven cents or a fraction over." The cost of production at the Jackson Iron Co.'s furnace in 1885, where the run was 50 tons daily, was as follows:

Items of cost.	$
1½ tons 62% ore	7 75
112 bush. charcoal	7 90
Limestone	25
Labor and office expenses	1 67
Cost of one ton of iron	17 57

The charcoal used at this furnace is made of equal quantities of hard and soft wood. "With all hard wood charcoal," Mr. McC. stated, "we can make iron with 95 bushels per ton." This quantity at five cents per bushel would reduce the cost to $14.47.

An estimate for iron ore of the Kingston district.

William Rattle of Cleveland, Ohio, a mining engineer and analytical chemist, gave evidence before the Commission at Kingston and stated that he had been intimately connected with the smelting of iron since 1872. In his opinion the ores of the Kingston district are as easy to smelt as those of the lake Superior district; he favors Connellsville coke for fuel, which could be laid down at Kingston at $5.50 per ton. Mr. Rattle's estimate of

the cost of producing a ton of pig iron, as extracted from his evidence, is as follows :

Items of cost.	$
Ore	4 00
Coke	5 50
Flux	25
Labor	1 00
Wear and tear, and interest	50
Cost of a ton of iron	11 25

"It would not be over $12 a ton anyway," he added; "all over and above that would be profit." If to this be added the government bonus of $1.50 and the customs duty of $4, it will raise the price to $17.50 per ton, and Mr. Rattle thinks that a margin of $6 should be ample encouragement. The cost of producing pig iron in Cleveland, he stated, was about $15, and Scotch pig was selling in that city at $21 after paying the duty of $7 per ton. At these rates the American iron makers have a profit of $6 per ton on coke iron selling at $21, while Ontario makers would realise the same profit by selling at $18 per ton.

Mr. E. C. Garlick of Cleveland, mining engineer and metallurgist, whose report on the Henderson steel process is given in the Appendix, has furnished the writer with an estimate on the making of charcoal iron, based on five years' experience in Ohio, which places the cost at $14.30 per ton. Following are his figures :

A Cleveland metallurgist's estimate.

Items of cost.	$
2 tons 50% ore at $1.50	3 00
Roasting ore at .37½	75
130 bush. charcoal at 6c	7 80
Limestone	50
Labor	1 50
Repairs and incidentals	50
Management	25
Cost of a ton of pig iron	14 30

This is for a ton of 2,240 lb. of pig iron, and by using No. 1 ore the cost may be reduced 75 cents. The estimate is intended to cover a period of fifteen years, but Mr. Garlick states that in the beginning the cost will not exceed $12 per ton. As against charcoal iron imported from the United States at a cost of $26 per ton, this would afford a profit of $11.70 to $14 per ton. Deep mining and long haulage of charcoal would increase the cost of ore and fuel; but with a furnace in a favorable location the effect of these causes would not be felt at the beginning of the enterprise.

A Detroit furnace man's data.

The following estimate is extracted from the statement of Mr. Gerhauser, secretary and treasurer of the Detroit Union Iron Co., which appears at the end of this Section and is for the long ton of pig iron:

Items of cost.	$
⅗ ton specular ore at $5.28	3 52
⅔ ton hematite ore at $4.48	3 00
⅓ ton magnetic ore at $4.96	1 65
87 bush. charcoal at 7½c	6 52
Limestone	06
Labor	1 37
Cost of a ton of iron	16 12

The cost of repairs, management, etc., is not included in this estimate. The iron ore is brought down from the Marquette district of lake Superior during the season of navigation, and the charcoal is brought in by railway distances ranging from 80 to 185 miles. It is made from two-thirds of hard and one-third of soft wood and costs about 5¼ cents per bushel of 20 lb. at the kilns. The pig iron is made expressly for car wheels and malleable castings, and its average selling price in 1888 was $19.52 per long ton.

Record of Iron Mountain furnace, Wisconsin.

A record of the Iron Mountain furnace at Ironton, Wisconsin, as given by the manager to the Journal of the Charcoal Iron Workers Association of the United States in 1883,* gives the details of a run of 69½ days. The total make in that period was 739¾ tons (2,268 lb.), the ore yielding 53.6 per cent. Following are the items of cost per ton:

Items of cost.	$
1.86 tons ore at $2	3 72
87.6 bush. charcoal at 6½c	5 70
694 lb. limestone	25
Labor	2 25
Oil and shop	08
Cost of iron per ton	12 00

The actual cost of the ore, the manager stated, was 80 cents per ton delivered at the furnace, but it was charged up at $2 to give the mine a profit. So also the actual cost of the coal was 6 cents per bushel, but a half cent was allowed for stocking and extra handling. The furnace was an old style stone stack, with hot oven and boiler at the tunnel-head, the stack 27 feet high and 7 feet 10 inches diameter at the bosh. When the size and facilities of this furnace are considered, the editor of the Journal observes, the record is truly remarkable.

The Journal of the Charcoal Iron Workers for 1881 gives the record of twelve furnaces during six consecutive weeks in the states of Michigan,

*Journal vol. IV, p. 23.

Missouri, Maine, Pennsylvania and Maryland, showing (1) the size of each furnace, (2) the average weekly product of pig iron for the period in long tons, (3) the estimated per cent. value of carbon in the fuel, (4) the average quantities of fuel, ore and limestone used to the gross ton of pig iron. The following table gives the statistics of the Michigan furnaces :*

Record of six Michigan furnaces.

Furnace.	Bosh.	Stack.	Carbon in fuel.	Heat of blast.	Fuel.	Ore.	Flux.	Weekly product.
	ft.	ft.	%	°	lb	lb	lb	tons.
Union Iron Co	10 6″	50	95	750	1,750	3,670	183	204
Leland	9 10″	45	95	425	1,848	3,997	153	183
Bangor	10 0″	43	93	850	1,936	3,720	130	312.8
Detroit Iron Co......	10 4″	52	95	860	1,970	3,770	151	266
Spring Lake.........	11 0″	45	94	850	1,980	3,690	136	344.2
Deer Lake	8 0″	47	94	750	1,691	3,756	164	178.3

For those six furnaces the average quantity of charcoal required to smelt a gross ton of pig iron was 1,862 lb., having a carbon value of 1,762 lb.; the average quantity of ore required was 3,767 lb., and the average quantity of limestone for flux was 153 lb. Their cost will depend on the quality of the ore and fuel and the distance of the furnaces from the sources of supply, but the figures will be found useful to some extent in verifying other estimates.†

Record of Detroit and St. Ignace furnaces

A record of the Detroit Iron Furnace company's furnace for a campaign of 413½ working days, ending June 28, 1882,‡ gives a total make of 17,257 gross tons (2,260 lb.) of pig iron from 57 per cent. ore, with 1,649,608 bushels of charcoal. The average quantity of charcoal used to make a ton of pig iron was 95½ bushels of 20 lb. per bushel. A Martel furnace at St. Ignace, Michigan, 53 feet stack by 10½ feet diameter of bosh, produced in 24½ working days in 1881, from 3,571,200 lb. of 59½ per cent. ore, 950½ tons of pig iron, using 1,420,250 lb. of charcoal, being at the rate of 1,494 lb. of charcoal for each ton of iron.§

Record of the Spring Lake furnace, Michigan.

A record of the Spring Lake Iron Co.'s furnace at Fruitport, near Grand Haven, Mich., is given in the Journal of the Charcoal Iron Workers for a run of 8¾ years, or 3,205 days.‖ It is a hot blast furnace, 45 feet high and bosh diameter of 10½ feet, and the average temperature of the blast is

*Charcoal Iron Workers' Journal, vol. II, p. 373.

†A comparison of 28 Swedish and 18 American furnaces published in the Charcoal Iron Workers' Journal, vol. III, p. 393, supplies the following data :

Bases of Comparison.	Swedish.	American.
Average height, ft................................	46	42 5″
Average diameter of bosh, ft......................	8 9″	9 8″
Average temperature of blast, F...................	410°	636°
Average weekly product, net tons	93.22	218.8
Ore and flux per ton of iron, lb	4,340	4,096
Ore and flux per lb. of charcoal, lb..............	2.225	2.2
Charcoal consumed per net ton of iron, lb.........	1,950	1,862

‡Journal of Charcoal Iron Workers, vol. III, p. 369.

§Journal, vol. III, p. 371. ‖Journal, vol. VIII, p. 273.

850°. The ore, which varies in the mixture from 58 to 61 per cent., is brought from lake Superior mines by rail and vessel; the limestone is brought by vessel from Kelly's island in lake Erie, and the fuel supply, which is made of two to one parts of hard and soft wood, is obtained at and near the furnace, the longest haul being 40 miles by railway. The total make of pig iron for the 3,205 days of running time—from March 4, 1880, to September 7, 1889,—was 153,999 gross tons, the average make per day being 48 tons, and the average quantity of charcoal required to make a ton of iron being 93 bushels of 20 ℔. each. Another record is given in the same number of the Journal for the Hinkle furnace of the Ashland Iron and Steel Co., located at Ashland, Wisconsin. In a period of 389 actual working days it made 29,398 gross tons of pig iron, being an average of 75½ tons per day, and since then it has made an average daily run of 90 gross tons. About 85 bushels of charcoal and 1¾ tons of lake Superior ore were used to make a ton of pig iron. The stack is a taper shell 60 feet in height and 12 feet in diameter at the base, and two fire-brick stoves heat the blast to a temperature of 900°. A record of the Antrim Iron company's furnace at Mancelona, Mich., for a run of 340 days, ending June 1, 1887,* gives an average of 81½ bushels of charcoal to make a gross ton of pig iron, smelted from an average of 3,754 ℔. of 60 per cent. ore mixed in the proportion of 80 per cent. hematite and 20 per cent. specular. The average quantity of limestone used for flux was 156 lb. per ton of metal, the average quantity of ore smelted per bushel of charcoal was 46½ lb., and the average number of gross tons made per day was 47½. The stack of the furnace is 48 feet high, the diameter of the bosh 8 feet 6 inches, and the average temperature of the blast for the period of the record was 850°. A record of the Tecumseh furnace in Alabama† gives statistics of 2,080 days running time, from 1875 to 1882, during which 35,927 tons of pig iron (of 2,268 lb.) were produced, of which 16,000 tons was No. 1. The ore was a brown hematite yielding 49.2 per cent., and the average quantity required to make a ton of iron was 4,550 lb. The quantity of charcoal required to make a ton of iron was 2,165 lb., and the quantity of flux 531 lb. of limestone. During the campaign the blast was maintained at an average temperature of 750° F. and the pressure varied from 1½ to 3 lb. per square inch, and the average make of actual working time was 17.27 tons per day. The cost of material, labor, management and other expenses are not given with any of those records; but this depends so much on the locality of the furnace that it is of less consequence than data of material and product.‡

Record of the Hinkle furnace, Wisconsin.

Record of the Mancelona furnace, Michigan.

Record of the Tecumseh furnace, Alabama.

Conditions governing the cost of ore and fuel.

The cost of ore at the mine is little more than the labor cost of raising it, which will be greater or less according as it lies in the ground, the depth from which it has to be taken and the effectiveness of the mining machinery used. The pig iron yield of the ore depends on its richness, but partly also on the character of the fuel used, the working qualities of the furnace and

*Charcoal Iron Workers' Journal, vol. VII, p. 208.

†See Journal, vol. IV, pp. 189-197.

‡Some high estimates of cost of production, published by the Journal of the Charcoal Iron Workers, are omitted because they were given with the avowed object of influencing tariff legislation.

the skill of the furnace men. A theoretically pure magnetic ore contains 72.413 per cent. of iron, and 3,093 lb. of this ore is required to make a gross ton of pig. Of 70 per cent. ore it requires 3,200 lb.; of 60 per cent. ore, 3,733 lb.; of 50 per cent. ore, 4,480 lb.; of 40 per cent. ore, 5,620 lb.; of 30 per cent. ore, 7,467 lb.; and of 20 per cent. ore, 11,200 lb. The cost of charcoal depends on the cost of wood and the method of producing it, and ranges from five and six cents per bushel in Wisconsin and Michigan to ten and twelve cents in New York and Connecticut. From numerous enquiries made during visits to American forests Sir Lowthian Bell estimated the cost of a ton of charcoal (112 bushels of 20 lb. each) to be as follows :

Items of cost.	s. d.
Price paid for timber as it stands on ground..............	0 8½
Cutting timber	5 3½
Charcoal burners and loading.....................	18 0
Total cost loaded into wagons at kilns......	£1 4 0

This is a fraction over five cents per bushel, but the price of transport varies according to distance. "Sometimes it is a mere trifle, but 5s. or 6s. per ton is a common charge for this item, and occasionally the carriage comes to as much money as the cost of the charcoal itself."* The cost of the iron ore, like that of the fuel, is added to by the freight ; so that every furnace must pay for raw material according to circumstances. For charcoal furnaces in Ontario the best location must be that which is nearest to the supplies of ore and fuel.†

Charcoal at Deseronto.

Mr. Rathbun of Deseronto stated to the Commission in his evidence that if iron smelting works were established in that town he could supply charcoal from kilns now in operation at six to eight cents per bushel, and he thinks iron could be smelted profitably with charcoal at eight cents per bushel. From a cord of wood he gets 50 bushels of charcoal, 4 coal oil barrels of liquid and from 800 to 1,000 feet of gas.

Mr. Bawden's evidence and paper.

The evidence of Mr. Bawden of Kingston relates the experience of a company in which he was interested in the production of charcoal ; but it is chiefly valuable for the information it gives on the employment of charcoal or coke enriched by water gas as a fuel for the manufacture of pig iron and steel, on the production of charcoal fuel from the waste material of saw mills and the possibility of utilising the splendid water power of Frontenac and Lanark in the iron smelting industry. Attention is also directed to Mr. Bawden's very instructive paper in the Appendix, in which a great deal of valuable information on the iron industry is presented.

*Principles of the Manufacture of Iron and Steel, p. 54.

†"The location of the blast furnace is originally determined by the relative positions, topographical and political, of the ores, the fuel and the fluxes used, and of the markets. Where the materials used are found in contiguous localities, as often happens, the furnace is usually located at a point as near as possible to that district. Where the materials are necessarily transported considerable distances the cost may be reduced by location near the ore bed."—Thurston's Iron and Steel, p. 144, 4th ed.

POSSIBILITIES OF PRODUCTION IN ONTARIO.

Production of charcoal iron in the United States and Sweden.

The countries which lead in the production of charcoal iron are the United States and Sweden, and both are favored by having large supplies of wood for the manufacture of charcoal. In Sweden soft woods such as pine are very largely used, together with the waste material of saw mills. In the United States the locations of the industry have shifted with the progress of settlement. Down to 1840 charcoal fuel was used almost exclusively in the smelting of iron ores, but since then mineral coals have been used extensively and the charcoal furnaces have receded to the backwoods. At the present time about one-half of the charcoal iron of the United States is produced in Michigan and Wisconsin, although the Salisbury district (embracing portions of Connecticut, Massachusetts and New York) continues to show no diminution. Iron smelting began in this district more than a century and a half ago, the first forge having been erected at Lime Rock in 1734, and the first blast furnace at Lakeville in 1762, and the fine quality of the iron made from the brown hematite ores of that vicinity has maintained a steady demand for it ever since. The average yearly production of charcoal iron in the United States for the ten years 1878-87 was very nearly 500,000 net tons, ranging from 293,399 tons in 1878 to 697,906 tons in 1882. In Sweden the average yearly production of the five years 1882-86 was 474,000 net tons, ranging from 439,637 tons in 1882 to 487,587 in 1886. Swedish iron enjoys the reputation of being the best in the world, and large quantities of it are imported into England every year in pigs, blooms and bars for the manufacture of cutlery and other purposes in which a fine quality of iron is required. But where good ore is used and intelligent methods are employed American charcoal iron is little if at all inferior to the Swedish; and although the conversion of iron into steel by modern economic methods has enabled manufacturers to use steel for many purposes in which charcoal iron was formerly regarded as indispensable, there is no cause to fear the displacement of charcoal iron, or any reduction in the present demand for it, except in the event of some discovery in the process of treating and improving the poorest qualities of iron that would put the invention of Bessemer under eclipse. In the present state of the industry, and with our present knowledge of the metallurgy of iron, the outlook for charcoal iron is sufficiently encouraging not only to justify makers in maintaining their present works but in the enlargement of their operations. The field in Ontario is unoccupied, and here, if anywhere, a favorable opportunity is presented for enterprise in spite of our record of failures. We have a home market of limited extent to supply, and with sufficient capital and under skilful and prudent management we should be able to find a foreign market also.

The prospect for its production in Ontario.

An American authority's opinion.

One of the estimates given of the cost of producing charcoal iron in Ontario in the foregoing pages was prepared by Mr. Birkinbine, secretary of the United States Association of Charcoal Iron Workers and editor of their journal. In an article on the possibilities of manufacturing charcoal iron in Canada, published in 1883,* Mr. Birkinbine states that he made several visits to our country to study the position she occupies and the rank

*Journal, vol. IV, pp. 337-47.

which she should take as an iron-producing country, travelling for more than a hundred miles through a section drained by the Ottawa river. "In the midst of some of the finest forests of the district lately visited," he says, "are outcrops of magnetic and specular iron ore, some of them of most encouraging character, and a number of lakes and streams offer favorable locations for the establishment of iron-producing industries. In this section also a number of mines are operated, producing a considerable quantity of ore of excellent quality, not one pound of which, so far as we could learn, is smelted in Canada. What ore is mined goes to the United States, being carried to lake ports by rail, thence transferred by boats to points in the state of New York, and from these shipped several hundred miles to blast furnaces to be smelted into pig iron, after paying a duty of seventy-five cents per ton. We very much doubt if a ton of the ore taken from the vicinity mentioned reaches a United States port on which the charges for railroad and water transportation and duty are less than from $1.75 to $2, independent of cost of mining the ore. When it is remembered that most of the ore exported is of a superior quality, (and it must be to bear the transportation and duty charges), that a considerable portion of it comes from a densely-timbered section, where land yielding fifty to seventy cords per acre can be purchased for two or three dollars per acre, that the Dominion government to encourage iron manufacture will for three years from July 1, 1883, pay a bonus of $1.50 for each ton of pig iron produced in Canada from Canadian ores and for the next three years $1 per ton, it seems strange that practically Canada is a non-producer of iron. We feel justified in making the assertion that we can locate furnace sites where charcoal iron can be made practically a permanent industry, where ore for a ton of iron would not cost more than from $4 to $5, where cordwood could for many years be laid down at the works at from $1.25 to $1.50 per cord, and where the distance to lake ports or other distributing points would be no greater than ore is now carried to be shipped to the United States. In short we are certain that superior charcoal pig iron can be made in Canada and delivered in its principal cities at a profit for the same price that ordinary English coke iron is now sold there." The same authority writing again in 1889* appears to think that, although the abundance of timber promises a supply of charcoal for an industry of considerable dimensions, and that there is a large field for the manufacture of iron with charcoal, the bulk of the iron in this country will most probably be smelted with mineral fuel. He accordingly favors the location of blast furnace works at Ottawa, as a convenient centre for the delivery of ores from mines in Ontario and Quebec and also for supplies of coke or anthracite coal from Pennsylvania. He expresses the opinion that under favorable railroad rates the cost at Ottawa of coke furnished in large quantities from the Connellsville district should be practically the cost at Chicago plus the duty of 60 cents per ton; but if coke made from coal in some of the northern counties of Pennsylvania were used "there would be a difference in distance of about 100 miles in favor of Ottawa as compared with Chicago to offset the duty." This assumes

Ontario ore exported to the United States.

The Canadian government's bonus.

A positive opinion on profitable production.

Iron smelting with mineral fuel.

* Journal, vol. VIII, pp. 290-8.

that the same railway rates could be obtained from Pennsylvania to Ottawa as from Pennsylvania to Chicago, which is not at all likely owing to the restriction upon trade between Canada and the United States and the consequent difficulty of obtaining return cargoes. But assuming the rate to Ottawa to be twenty-five cents per ton higher than to Chicago, he estimates the cost of coke delivered at Ottawa with duty paid at $5.10 per ton, and anthracite coal would cost about the same. The cost of roasted iron ore of 60 per cent. richness he estimates at $2.55 per ton delivered, and the flux necessary to smelt a ton of iron at fifty cents. With these data Mr. Birkinbine makes the following estimate for the cost of a gross ton of pig iron:

An estimate of cost of production.

Items of cost.	$
1⅔ tons of ore at $2.55	4 25
Fuel	6 50
Flux	50
Labor, repairs, office expenses, etc	2 75
Cost of a ton of iron	14 00

This figure, he states, is possibly above what practical operation may demonstrate as the actual outlay, but it is still sufficiently low to encourage operations which will displace at least a part of the 50,000 tons of pig iron annually imported into the Dominion, or furnish material to produce a portion of the 250,000 tons of manufactured iron which enters Canada every year from other countries. And then Mr. Birkinbine proceeds to answer the question, "Can pig iron be produced in the Dominion to compete with foreign metal?" "The Canadian duty," he says, "is now $4 per net ton on pig iron—the estimated cost above is per gross ton. In addition the government offers a bonus of $1 per net ton on all pig iron made in Canada from Canadian ores; therefore the domestic metal would be protected at least until the expiration of the bounty period to the extent of $5 per net ton, or about $5.60 per gross ton. If now pig iron at Ottawa costs $14 per ton foreign metal would have to be delivered there at $8.40 per ton to meet this cost. But an allowance for profit must be made; including this, as well as the percentage of loss from bad debts, and also adding liberally for possible discrepancies in the estimate, say $2.60, the domestic product could meet foreign iron delivered at Ottawa at $11 per ton. As the iron is shipped away from Ottawa freights must be added, but there still seems to be ample margin to encourage the production of domestic pig iron in Canada. The estimates offered are for the production of pig iron using anthracite coal, coke, or a mixture of these two fuels, but the subject should not be dismissed without considering the possibility of employing charcoal as fuel, and considerable discussion has from time to time been had upon the utilisation of the enormous waste from the mills at Ottawa by converting it into charcoal. The slabs and larger refuse could be charred in kilns, but most of the timber now used in the mills is of a character producing charcoal of inferior quality for blast furnace use. Improvements in manufacture are also utilising much of the waste for special products, which

Can pig iron be produced in Canada to compete with foreign metal?

An ample margin.

Charcoal iron:

reduce the chances of a permanent supply for this purpose. There seems to be more encouragement to convert the sawmill refuse and sawdust into gaseous fuel, as in Sweden, and use it for manufacturing iron and other metallurgical purposes. Gas producers for this purpose would have to be equipped with condensers, for the refuse material supplied to the producers would carry 40 per cent. or more of water. If pig iron is produced in the vicinity of Ottawa there would seem to be good encouragement for investigating the economical employment of this waste material, and also the possible utilisation of some of the water-power available in the vicinity. As noted before, the production of charcoal pig iron apparently offers greater advantages at some of the localities where the ores and hardwood timber are contiguous. The charcoal required for smelting a ton of pig iron would probably cost from $7 to $8 at Ottawa, from $1 to $2 in excess of the cost at the other points indicated. As this charcoal iron would be used for special purposes, it would command a correspondingly high price in the market." Assuming the furnaces to be erected in one of the well-timbered districts in the vicinity of the iron mines, the cost of producing charcoal iron, according to this latest estimate of Mr. Birkinbine, would be $13.50 to $14.50 per gross ton, and it has been shown that the cost of imported charcoal pig to consumers ranges from $26 to $38 per ton. Apparently, then, the possibilities of producing charcoal iron in Ontario are sufficiently encouraging, and with a profit of 100 per cent. upon sales made at the lowest price of imported American charcoal iron the industry should be a fairly remunerative one.

The range of estimated profits.

TREATMENT OF MAGNETIC ORES.

In his remarks upon ores in the vicinity of Ottawa Mr. Birkinbine observes that those nearest the city are generally sulphurous,* but that this should not necessarily condemn them in view of the facts that over one million tons of sulphurous magnetites are annually smelted in the United States and that some of the American furnaces which have been most successful financially have used entirely or largely such ores. Blast furnace practice, he states, has shown that it is difficult to produce good foundry grades of pig iron with dense magnetites, especially if they carry considerable sulphur. "But modern plants, improved methods and chemical research have done much to remove these troubles, and it is not prophecy to state that with a well equipped and properly managed plant, using thoroughly roasted magnetites instead of ore partially calcined, satisfactory work in this particular can be obtained."† There are few difficulties in nature which the ingenuity of man cannot surmount, and science has already won many triumphs in the treatment of unclean ores. Only a few years ago the practice was to roast sulphurous ores in lumps of any size as taken from the mine, and some of our dense Ontario magnetites were condemned at Ohio and Pennsylvania furnaces because it was found that the roasting which was sufficient with less compact ores was in their case only superficial, showing effect only to the depth of half an inch or an inch according to the heat used and the time taken in roasting. Now the practice is to break up hard ore to a uniform

Sulphurous magnetic ores.

Unsuccessful roasting.

An improved process.

*This applies more particularly to the mines on the Quebec side of the Ottawa river.

†Journal, vol. VIII, p. 294.

size by running it through a crusher, such as the Blake or the Gates. The New Jersey and lake Superior magnetic ores are treated in this way, and with improved roasting furnaces the process is found to be very satisfactory. But there are various other methods employed in preparing ores for the smelting furnace, one of which is worthy of special mention because of the success claimed for it in cleaning magnetic ores.*

The magnetic treatment.

One of the first, if not the first, to suggest the application of magnetic treatment to magnetic ores containing sulphur, titanium or phosphorus was Dr. Sterry Hunt. In his report on Iron and Iron Ores in 1869† he refers to a massive granular titaniferous ore at St. Francois, on the Chaudiere river, Quebec, which consists of a mixture of about two-thirds magnetic oxide of iron, and one-third of a titanic iron holding not less than 48 per cent. of titanic acid. The two, he stated, were readily separated by a magnet, "and it is probable that by a magnetic separating machine it will be possible to make use of this and of similar ores for the preparation of iron in the direct way, to which the purified magnetic oxide is well adapted." In the case of a magnetic ore found on an island in Mud lake, in the township of South Crosby, which contained nearly 10 per cent. of titanic acid and 1½ per cent. of sulphur, he found that "when the pulverised ore is treated with a magnet it is partially purified, the non-magnetic portion retaining the sulphur and a large part of the titanium. The magnetic portion equalled 74.2 per cent., and contained 54.76 per cent. of metallic iron and 5.70 of titanic acid."‡

Sterry Hunt's use of the magnet with hand specimens of impure magnetic ores.

Dr. Hunt also mentions a great mass of iron ore found on Rapid river, which empties into the bay of Seven Islands, containing nearly 34½ per cent. titanic acid. "When pulverised and treated by a magnet it was separated into two portions, one strongly magnetic, equal to 57 per cent. The remainder gave by analysis 51.14 of titanic acid and 39.75 of peroxide of iron, besides 8.30 of insoluble residue. The magnetic portion, contrary to what might have been expected from the readiness with which it was attracted by the magnet, contained not less than 24.80 per cent. of titanic acid. It was nearly free from silicious impurities, and almost wholly soluble in hydrochloric acid."§ In many magnetic ores the sulphur, phosphorus, etc., are for the most part physically united with the iron, and in such cases separation with a magnet after crushing takes place readily; but where the substances are chemically united separation by the magnetic process cannot be looked for.

The germ of an important invention.

Whether Dr. Hunt was the first to employ the magnet upon hand specimens of ore in the way here indicated or not, it is certain that the experiment contained the germ of a very important invention.

Buchanan's magnetic separator.

The first magnetic iron ore separator of which the writer has found an account was the invention of C. G. Buchanan of Rockaway, New Jersey, and was used to treat black magnetic sand containing a large percentage of titanic acid. In a paper read before the U. S. Association of Charcoal

*The washing process, which is used in reducing the earthy matter of hematite and specular ores, is an old but serviceable invention, and where there is a good supply of water it is worked at very small cost. At the Old Hill mine in the Salisbury district, Connecticut, machinery for crushing, washing and screening the ore reduces the material as hoisted from the mine to 25 per cent. of its bulk, that is to say, of 100 parts raised 75 are washed away, being earthy matter of no value.

† Geological Survey report, 1866-9, p. 253. ‡ p. 258. § p. 260.

Iron Workers in 1881 Mr. Hoagland, the manufacturer of this machine, stated that it separates the magnetic sand so thoroughly that none of the titanium is found in the portion which passes over the magnet; "in fact where properly managed the product of the machine will yield by analysis 71 and 72 per cent. metallic iron." The results of the separation were so satisfactory, Mr. Hoagland went on to say, that parties who have other ores than black sand have used machinery invented by Mr. Buchanan to pulverise and separate them, preferring the magnetic process because the fine ore which is washed away by the jigging process is all saved, the magnet leaving less than two per cent. of ore in the tailings.* The machine is composed of two iron cylinders parallel to each other and supported at each end by a pair of horse-shoe shaped iron standards, with journals in which the axes of the cylinders play when the machine is in motion. The standards are insulated and are closely wound with heavy insulated copper wire, so that when charged they become powerful electro-magnets, with positive and negative poles. The cylinders become magnetised by induction, and in this way a magnetic field is formed between them, capable while the machine is in operation of holding a weight of 500 or 600 lb., but non-magnetic on the opposite sides. The whole is set in a strong wooden frame, the standards being firmly bolted to cross timbers at the base, while a pair of hoppers over the cylinders hold the pulverised ore which is to be treated. The operation of the machine is described as follows: The cylinders are rotated towards each other at a speed of from 60 to 75 per minute, and the hoppers are opened by regulated slides so that the ore falls upon them. Being carried between the cylinders into the magnetic field, all that is magnetic is attracted and attached to the faces of the cylinders and is carried round to a point where they lose their magnetic effect, when it drops into shoots. The earthy and all other non-magnetic components of the pulverised ore are acted upon by gravity alone, and falling undisturbed through the magnetic field a nearly perfect separation is effected. The separators are built in three different sizes, ranging in capacity from 20 to 100 tons per day.†

Operation of the machine.

The Conkling magnetic concentrating machine has been used to treat magnetic iron ore containing phosphorus, and its construction is thus described: The pulverised ore is discharged from a hopper to a feed-belt which delivers it into a narrow shoot, from which it drops upon a horizontal india-rubber belt running at right angles to it at a speed of 1,000 feet a minute. Above the lower surface of this belt are placed vertically two electro-magnets. These cause the magnetic particles of the ore to adhere to the belt which carries them away laterally, the tailings remaining on the feed-belt and discharging into a shoot. The concentrates fall upon a second feed-belt, pass under a second magnetic field, and finally under a third.‡ Ore dressing experiments with this machine are given as follows: The crude ore from Lehigh mountain contained 39 per cent. of iron and .038 per cent. of phosphorus, whilst the concentrates contained 66.24 per cent. of iron and .005 per cent. of phos-

The Conkling magnetic concentrator.

Test experiments.

* The Charcoal Workers' Journal, vol. II, p. 322-3. † Journal, vol. III, p. 400.
‡ Journal of the Iron and Steel Institute, No. 2, 1888, p. 189.

phorus. Mount Hope ore containing in its crude state 58 per cent. of iron and .1 per cent. of phosphorus yielded concentrates with 70.47 of iron, .023 phosphorus and 1.27 silica.

Edison's magnetic iron ore purifier

A magnetic iron ore purifier invented by Thomas A. Edison and set up in his laboratory at Orange, New Jersey, was seen in operation by the writer in June, 1889. It consists of a series of crushers which reduce the ore to a 20-mesh, and a powerful magnet which separates the pulverised ore into its magnetic and non-magnetic parts. The ore is broken and pulverised in a series of crushers and rollers and sifted through an oblique screen, whence it is carried by elevators to a V-shaped hopper over the magnet. This hopper is about six feet long with a bottom of two iron plates, one of which is nicely adjusted to open and close by a screw. When in operation a regulated stream of the ground ore descends from the hopper in front of the magnet—a massive bar of soft iron charged from a dynamo—by which the iron is deflected and separated from the non-magnetic portion of the ore. A thin movable partition of sheet iron set in a light wooden frame is placed on the floor, in a position to divide the concentrates from the tailings. The bar is magnetised to any required power, and the simple process of drawing the magnetic particles of iron out of the vertical separates it from all free non-magnetic impurities, such as silica, sulphur, phosphorus and titanium. It does not seem likely that where these are chemically united with the iron they can be separated from it; but they exist to a greater or less extent free, and where this is the case and the ore is finely pulverised they separate readily. Mr. Edison has had analyses made which show that the proportional quantities of titanium, phosphorus, etc., have been largely reduced. Besides, the process gives an ore of much greater richness, for while in the native state it may only be 50 per cent. it can be increased by eliminating the impurities to 60, 65 and even 70 per cent. This has been proven by experiments carried on upon a large scale with ores in New Jersey and Pennsylvania, the concentrates of which are sold to local furnaces. Mr. Edison and others with him have bought mining properties in Pennsylvania the ores of which contain only 30 per cent. iron, with large proportions of lime and apatite in the gangue, and they have a mill in operation with a capacity of 250 tons per day which increases the iron in the concentrates to 50 per cent. and very considerably lowers the percentage of phosphorus. When asked if he did not fear that the finely pulverised ore would be difficult to smelt by reason of its smothering the stack, Mr. Edison said he thought it would not as in Sweden they had smelted pulverised ore successfully; he thought the coal and flux would keep it sufficiently open for draft.* Mr. Edison believes also

Operating in commercial quantities.

*Phillips in his Metallurgy of Iron says that on account of their fine state iron sands have not been successfully employed for the production of cast iron, but at the Moisic works they are directly converted into wrought iron in a bloomary furnace with satisfactory results. The Journal of the Iron and Steel Institute, (No. 2, 1888, p. 186), records that in concentrating the poorer quartzose ores of Norberg, in Sweden, the practice at first was to manufacture the crushed ore into briquettes with the aid of lime; but as it was found that these disintegrated during the transport from the mine to the works the plan was tried of mixing the pulverised ore with lime and adding a small portion of red hematite to the charge, in the proportion of 6.7 cwt. powdered ore, 2.3 cwt. red hematite and 0.7 cwt. lime. "The size of the powdered ore varies, half being in the form of dust and half in pea-sized fragments. The furnaces work excellently, and the pressure of the blast had to be raised only very slightly. It is thus evident that the moulding into briquettes is unnecessary. At the same time the

that by using a high stack sufficient heat will reach the ore within five minutes of putting in the charge to drive off any remaining portion of sulphur contained in the ore. With experience gained in the laboratory and in a commercial way at the mills now in operation, Mr. Edison feels warranted in making the following claims for his machine: (1) That it will crush and separate the ore at a loss or waste of only $1\frac{1}{2}$ or 2 units of iron. (2) That with ore containing 40 per cent. of metallic iron as mined it will produce concentrates averaging 65 per cent. (3) That it will treat at a profitable rate ore containing as low as 20 per cent. of iron, without throwing any portion of it in the waste heap or sorting it into second class piles. (4) That by grinding all ore raised from the mine down to 20 units, the cost of mining may be reduced 40 or 50 per cent. and 30 per cent. of the ore as mined may be saved—the usual practice being to throw all ore carrying less than 40 per cent. of iron into the waste heap. (5) That it will reduce the phosphorus in magnetic ores by 75 to 80 per cent. (6) That a machine of 1,000 tons daily capacity will mill and refine ore up to 65 per cent. iron at a cost of seventy cents per crude ton. (7) That Canadian magnetic ore carrying an average of 50 per cent. metallic iron can be concentrated to 68 per cent. and delivered in Cleveland duty paid against 65 per cent. ore from lake Superior.

Claims made for the Edison machine.

At the iron mines of Witherbees, Sherman & Co. near Port Henry, on the New York side of lake Champlain, two magnetic separators were tried in the spring and summer of 1889. The Ball, Norton & Porter separator, made at West Troy, was in use for three weeks in March, after which it was taken to a mine at Little River in the Adirondacks and was worked there during the summer. It consists of two leather belts, 13 inches wide and running on rollers three feet apart, one close above the other and lapping about half its length. A stationary magnet composed of ten bars of iron, alternately positive and negative, is placed within the upper belt so as to overlap the lower one. The ore is crushed to a size varying from one-quarter of an inch to a 16-mesh, and is fed through a hopper upon the lower belt, which in motion revolves at a speed of 300 feet per minute. The upper belt, within which is the magnet, revolves in the contrary direction at a speed of 150 feet per minute. When the machine is in operation the ore is carried forward on the lower belt until it comes within the influence of the magnet. Then the particles of iron are drawn to the upper belt and are borne along as far as the power of the magnet extends, to drop through a shoot into the pile of concentrates. All the non-magnetic particles are carried by the lower belt past the roller and are drawn off into another shoot by a fan placed at its mouth for that purpose. The capacity of this machine is about five tons per hour. The second machine, which the writer saw in operation in the latter part of June, 1889, is a Swedish invention, known as the Wenstrom. The right to use it in the United States was acquired during the previous winter by Robert A. Cook of New Brunswick, N. J., and several

The Ball, Norton & Porter magnetic separator.

The Wenstrom magnetic separator.

use of the powdered ore induces a considerable saving of coal, whilst the percentage of iron has increased. The latter amounts to 65. The cost of the concentration, from 40 up to 60 per cent. of iron, does not exceed 2s. 6d. of powdered ore." The concentrates produced by Edison's mill in Pennsylvania are ground to 10-mesh, and are mixed with regular large ore in the proportion of one part to four.

machines were imported. The essential part is a cylinder whose rim is made up of alternate bars of soft Swedish iron and wood revolving upon a fixed axis and magnetised by a strong electro-magnet in the interior, held in eccentric place by the axis. When in motion the iron bars of the cylinder become a successive series of positive and negative magnets as they approach the side on which the magnet is fixed, and change to the non-magnetic state with equal regularity as they revolve to the opposite side. Any ordinary breaker like the Cornish rolls may be used to crush the ore, which is fed through a hopper and falls upon a polished brass slide the lower edge of which approaches within three-eighths of an inch of the cylinder. There the iron is drawn to the magnetised bars of the cylinder, to be carried around and dropt off at that point in the circumference where the bars become demagnetised, while the gangue material falls from the brass plate unaffected by the magnet to be carried off to the dump of tailings. Mr. Cook claims that the machine will separate all magnetic substances from non-magnetic when they are crushed so as to be broken free from each other. "If sulphur, phosphorus, or titanium are non-magnetic they will go with the waste, but both the sulphur and titanium may be there in the form of a magnetic mineral, and in that case they would stay with the iron." It was also noticed that where the ore was not broken very fine, grains of apatite to which particles of iron adhered were attracted by the magnet and added to the pile of concentrates. Thorough pulverising seems to be necessary in treating the Port Henry ores by this process. The machine has a capacity of six tons per hour, and the New York selling price is $1,800. The following analyses of results from both machines, each working on crude ores containing 41.06 per cent. iron and .25 per cent. phosphorus has been furnished by Mr. F. S. Witherbee, of Witherbees, Sherman & Co.:

What the Wenstrom machine can and cannot do.

Thorough pulverising necessary.

Comparative esults.

Material.		Wenstrom.	Monarch.
		Per cent.	Per cent.
Concenrates	Iron	61.00	64.00
	Phosphorus	0.09	0.06
Tailings....	Iron	25.00	12.00
	Phosphorus.........	0.39	0.53

A second test with crude ore containing 59.1 per cent. iron and 1.24 per cent. phosphorus gave the following results with the same machines :

Material.		Wenstrom.	Monarch.
		Per cent.	Per cent.
Concentrates	Iron	61.08	64.05
	Phosphorus	0.84	0.64
Tailings.....	Iron	14.3	10.08
	Phosphorus	3.09	2.07

Mr. Witherbee states that neither of those machines seems able to work wet ore, and that no magnetic separation can be regarded as a success until some process is found to work ores from damp mines or in damp weather.

"I believe the only way magnetic separation can be tested," he writes, "is to work out the problem for each individual mine, and that takes time and money. Not having had an opportunity to work the machines for any length of time we hesitate to advise which is best, for we do not know ourselves. But we have made up our minds to one thing, and that is that you cannot afford to separate any ores running below say 45 or 50 per cent. and pay the cost of mining unless you have to mine them in order to reach ores running above 60 per cent." In this opinion, it will be observed, Mr. Witherbee differs from Mr. Edison, who has had the experience of a mill running several months upon the low grade ore of a Pennsylvania mine. As regards the smelting properties of pulverised ore, it is the testimony of Port Henry furnace men that iron ground to the fineness of sand and mixed in the charge with coarser ore in equal parts does not affect the furnace, but smelts freely.

Conditions of economic separation.

The electrical treatment of iron ores is of so recent origin, and the means of applying it are already so varied, that many improvements in mechanism may be looked for with confidence.* The results obtained from several of the machines appear to have demonstrated to practical iron men that in the application of the principle of magnetic separation a most valuable gain has been made to our knowledge of the metallurgy of iron. To be able to save the iron in lean and clean ores, which usually are thrown into the waste heap, is itself a great attainment in the economy of iron production, for in all mines much lean ore is raised. But if, in addition, the smelting properties of rich ores containing a low percentage of impurities may be improved, and if ores valueless in the state of nature by reason of the high percentage of their impurities may be made valuable by the process of magnetic separation, the utility of the method can hardly be over-estimated.

Possibilities of electrical treatment.

ECONOMIC TRANSPORTATION.

The iron industry as now carried on in most countries demands the employment of every possible means for cheapening the cost of production. To move the ore from the mine to the furnace or the nearest point of shipment is often expensive, especially in a rugged and broken country, or in the backwoods, where good roads cannot be built, or if built cannot be kept through all seasons in a proper state for the traffic over them ; while the cost of constructing a railway can only be afforded by mines of large production. As a means of transportation for short distances wire-rope tramways have been in use for some time, but until recently in America these have consisted of a single, moving, endless rope, from which the loads are suspended. These lines, while very efficient for certain purposes, are not available for general use as a means of transportation, as in no case does their carrying capacity exceed 300 lb., and in practice it is much less. At Capelton, Quebec, one has been put up by Cooper, Hewitt & Co. of New York, and although designed to carry 300 lb. this burden was found to strain the rope too much and had to be reduced. The single-rope line has been almost entirely supplanted in Europe by the Bleichert double-rope system,† which has already

Use of wire-rope tramways for moving ore.

Single-rope lines.

The Bleichert double-rope system.

*It is understood that Mr. Edison has constructed a new machine which is in several respects a very marked improvement upon the first one.

†It is constructed under what is known as the Bleichert patent, and consists of a stationary rope to support the load and a moving one to carry it.

established itself as a means of transportation hardly yet dreamt of on this side of the Atlantic. Railroad companies have adopted the lines of this system as regular feeders to their main roads, and laws have been enacted regulating their construction and traffic the same as for ordinary railroads.

Advantages which it presents.

Amongst the advantages which the Bleichert system presents over any of the single line systems are the following: (1) While the loads carried by single lines are seldom over 100 lb. the Bleichert lines are adaptable to individual loads up to 2,000 lb. (2) In the single-rope systems, where the moving rope carries the load, there is great danger in rapid movement that the rope may jump out of the carrying sheaves, which are made very shallow so as to permit passage of the saddle over them. In the Bleichert system the stationary rope has no tendency to get out of place, and there is no difficulty in moving the cars over it at a speed of four or five miles per hour. (3) With single-rope tramways a grade of 1 in 4 is about the limit, as on steeper grades the load is liable to slip on the rope, unless a clip is used which fastens the bucket; but in the latter case the buckets must be loaded and unloaded while in motion, since they cannot be stopped without stopping the whole line. In the Bleichert system any grade up to 1 in 1 is overcome, and when the car reaches either terminus or any switch on the line it can be automatically disconnected and run off to any point required for loading and discharging. The cars may be run down into a mine, loaded at the face of the working and delivered to any point on the line without handling of the material. (4) The carrying-rope, being stationary, can be locally graduated to the strain it bears; but of course the one for empty cars does not require to be as strong as the rope for loaded ones. So, also, where short spans occur it is not necessary that the rope should be as strong as the sections suspending long spans; it is sufficient to strengthen only the portions exposed to extra strain. In this way great economy in the total weight of the ropes is effected, whereas in the case of the single-line system the rope must be of uniform weight and strength throughout. The ordinary spans used in the construction of the Bleichert tramways are 150 to 200 feet, but they may be much longer, spanning valleys and rivers 1,000 to 1,500 feet across. The Weilburg tramway in Germany, which has a total length of seven miles and a daily carrying capacity of 250 tons iron ore, crosses the Weimbach river with a span of 1,000 feet in the clear. The cost of operating depends on the quantity carried. A line at Lintorf, Germany, two-thirds of a mile in length, carries 60 tons per day at a cost of $4\frac{1}{3}$ cents per ton, counting labor, interest on capital, wear and tear, etc., and by increasing the capacity to 100 tons the cost is reduced to a little over $3\frac{1}{2}$ cents per ton. These figures, the manager of the Lintorf mines and smelting works says, are inclusive not only of actual transportation, but of the delivery of the coal and ore exactly at the spots where they are to be used, so that no further handling is required. A line constructed at the mines of the Bi-Metallic Mining company in Montana, and put into operation on May 8, 1889, was reported upon by the superintendent of the works under date of August 12 as follows: "Since starting we have transported about 85 tons of ore per day from the mine at Granite to the mill at Clark, a distance 9,750 feet, and have also carried up to the mine

Cost of operating the tramway.

the greater portion of the supplies used there, running tramway about six hours per day, at an average cost of 22 cents per ton. By running tramway for twelve hours per day to its full capacity we could carry 240 tons with practically the same force as is now employed, thus reducing the average cost to from 10 to 12 cents per ton. When the line is carrying its load it develops sufficient power to run a 9 by 15 Blake crusher, and crushes all the ore raised at the mine."* A line constructed for the Granite Mountain Mining company at Rumsey, Montana, for the transport of the silver ore has a length of 8,750 feet and a carrying capacity of 300 tons daily. It has one span of 600 feet and in one section of 1,800 feet it has a fall of 800 feet, being a grade of nearly 1 in 2. One erected at the gold mine of the Nowell company at Juneau, Alaska, has a length of 11,600 feet, with difference in level between terminals of 2,135 feet and a daily carrying capacity of 200 tons. But the longest line in operation in America is one constructed for the Split Rock Cable Co. of Syracuse, N. Y., the length of which is 16,500 feet and the daily capacity 750 tons. It was built for the transportation of lime rock, and at the discharge terminal the loaded cars are run upon a suspended rail over a series of kilns, into any one of which by an arrangement of switches they may be unloaded without delay and immediately started upon the return trip. Quarry cable hoists are also constructed on the same plan, one of which is in operation at Rockland, Maine; it has a span of 865 feet, and the carrying capacity is 6 tons per load. There seems to be no doubt that the adoption of this system of transportation would greatly simplify and cheapen the cost of mining operations in Ontario, especially in such districts as northern Hastings, Haliburton and Sudbury, where high rocky ridges and intervening valleys are a feature of the country.

Lines in the United States.

ROLLING MILLS, STEEL WORKS AND MANUFACTURES.

A beginning has been made in Ontario in the manufacture of rolled iron, but the most that can be said of the industry here is that it is still in its infancy. It is perhaps too much to expect rolling mills to flourish until we have succeeded with the production of pig iron, and the same remark applies to steel works. The industry however is of first class importance, and if established and conducted under skilful direction and by the most approved systems, using pig iron produced from our own ores, it should give a profitable employment to labor and safe investment to capital. But the plants required for rolling mills and steel works are expensive, the best modern methods require to be adopted, and careful, intelligent management is a necessity. The cost of producing rolled iron and steel has been greatly lessened within the past ten years by the substitution of mechanical for hand labor, just as the cost of converting iron into steel has been lessened by the invention of Bessemer. At the present time new processes are being tested in the United States, and the hope is entertained that steel may be made direct from the ore at little more than the cost of pig iron. These processes are being watched with great interest, and to no people should they possess more value than to those who in a country like Canada may have the erection

An industry in its infancy.

The best modern methods and intelligent management a necessity.

New processes being tested.

*Letter to Cooper, Hewitt & Co., who hold the American agency for the Bleichert wire tramway system. Their works are at Trenton, N. J.

of steel works in contemplation. It is not by the adoption of ancient and effete methods that an industry can be established in the face of present day competition, but by the employment of the latest, most perfect and most economical means, having regard for the qualities of the iron to be treated and the market to be supplied.*

Relative prices of raw material and manufactured product.

A word may here be said of manufactures of iron and steel goods, and especially of their value to a country in the employment which they give to skilled labor. In some lines of manufactures, such as cast metal pipes and railway chairs, the share of labor in the finished article is relatively small; but even in pipes the price of the pig iron is doubled. Stove grates and kitchen ranges are worth from three to five times the price of the iron, while a locomotive and its tender are worth about nine times and vessel machinery about ten times that of the raw material used in their construction. Common needles, such as Britain exports to China, made from Bessemer steel wire which costs the manufacturer £60 per ton, sell for £260 per ton, while the needles for home use sell at £5,600 per ton. The wire used in the manufacture of the finest fish-hooks costs £336 per ton, and the hooks themselves sell for £14,000 to £15,000 per ton. The main springs of watches sell for about £6,000 per ton, while the retail value of hair-springs is about £400,000 per ton, or three times the price of gold.†

SERVICE OF INVENTION TO THE METALLURGY OF IRON.

The industry built up by skill and invention.

Any report on the iron industry would be very imperfect which did not attempt to show how much it owes to invention. It could have had no existence without the raw materials of ore and fuel; it could have had no beginning without labor; it could have made no progress without the support of capital; but without the aid of invention the industry would be still in puling infancy. In every step and stage of the business, from raising the ore out of the earth to the finishing touch upon the manufactured metal, the ingenuity of man is found overcoming the forces of nature, lightening labor, cheapening production, improving the qualities of the material itself, finding out new uses for it in the arts and adapting it in a thousand ways to the wants of an advancing civilisation. Mining of any kind would have been difficult and costly, and deep mining would have been all but impossible, but for the service of the air compressors, the drills, the explosives and the hoisting apparatus now employed at every well-equipped mine; while means of cheap and rapid transit of ores and methods of treating them in preparation for the smelting furnace have made properties workable and valuable which otherwise might have remained unused and idle to the end of time. It would be unfair to those who were engaged in the manufacture of iron during even the first half of the present century, an eminent authority on the subject has recently said, to deny the services which they succeeded in rendering to their art without much thought being given to those laws of nature upon which

*The Henderson process is described in the Appendix as tested at Birmingham, Alabama. Another process of direct conversion is soon to be tested upon magnetic ore from the Bristol mine, near Ottawa, at Findlay, Ohio, where extensive works have been erected under the management of a gentleman trained for twenty years under Sir William Siemens. The fuel to be used at the Findlay works is natural gas, which is found there in great abundance.

† See Sir Lowthian Bell in the Reign of Queen Victoria, vol. II, pp. 234-5.

their processes depended; but, on the other hand, it is not to be denied that since the iron masters have allied themselves with the chemist "they have made more progress in thirty years than their predecessors did in three centuries."* In what ways, then, has the prosperity of the industry been served by skill and invention? and is any other agency or policy likely to be of equal or greater utility?

Nearly a hundred years ago Mungo Park found a smelting furnace or forge in the interior of Africa built of clay, about ten feet high and three feet in diameter, in which iron ore was smelted with charcoal fuel. The charge was built up with alternate layers of ore and coal, fire was applied through openings at the base of the stack and blown with bellows made of goats' skins, and at the end of three days it was allowed to cool off. Part of the furnace was then taken down, when the iron was found in the form of a large irregular mass, with pieces of charcoal adhering to it. "It was sonorous," Park says in his account, "and when any portion was broken off the fracture exhibited a granulated appearance like broken steel. The owner informed me that many parts of this cake were useless, but still there was good iron enough to pay him for his trouble."† A quarter of a century ago Captain Grant published a journal of his walk across Africa from the south-east coast to the head waters of the Nile, and he too describes a forge which if possible was more primitive than the one described by Mungo Park. It was found in the territory of the Walinga, who are spoken of by way of distinction as workers in iron. "Their furnaces are in the heart of the forest; charcoal and lumps of iron cinder (like a coarse sponge and of a 'blue-bottle' color) usually mark the spot, and four lads squatting under a grass roof, with a double-handled bellows each, blow at a live mass of charcoal which has the nodules of metal intermixed with it. In this calcining nothing else seems to be used, and the metal melts, decending into a recess much in the same way as I have seen at the Cumberland lead works."‡ The natives of Africa have made no progress in the metallurgy of iron from the first discovery of the process of reducing the ore to metal; but the means they employ is the principle of the Catalan forge, used in Europe and America down to the present time in the production of blooms or malleable iron, and consisting essentially of a furnace, a blowing machine and a heavy hammer.§ It is the direct process, and

Primitive iron-making as witnessed by Mungo Park and Captain Grant in Africa.

The Catalan forge.

* Sir Lowthian Bell at the British Association's meeting, 1889.

†The Life and Travels of Mungo Park, p. 230-1, Nimmo's ed. "This iron, or rather steel, is formed into various instruments by being repeatedly heated in a forge, the heat of which is urged by a pair of double bellows of a very simple construction, being made of two goat's skins, the tubes of which unite before they enter the forge and supply a constant and very regular blast. The hammer, forceps and anvil are all very simple, and the workmanship (particularly in the formation of knives and spears) is not destitute of merit. The iron indeed is hard and brittle and requires much labor before it can be made to answer the purpose."—p. 231.

‡Captain James A. Grant's Walk across Africa, p. 130. (Blackwood, 1864.)

§ Dr. Percy in his valuable work on the Metallurgy of Iron and Steel says: "The Hindoos appear to have carried on the direct process from time immemorial, as we may certainly infer from the large accumulations of clay which occur in various localities in India; and as it is scarcely possible to imagine anything more rude than their appliances, or anything more diminutive than their scale of operation, it would seem that they have not made any substantial progress in their art, at least in many districts. Their furnaces are frequently not larger than a chimney-pot, and hours of incessant toil are required to produce a few pounds weight of iron; and yet the price at which they sell the metal is surprisingly low." (p. 254). The furnace is built and the blast is produced much the same in India as in Africa;

it was the only one known generally to Europeans down to three centuries ago.* When or in what manner the indirect process was discovered no one knows definitely, but it was the beginning of the age of improvement in iron production. In the German Stuckofen with a stack of 10 to 16 feet high, and the Blauofen with a stack sometimes 25 feet high (which constituted the difference between these furnaces and the Catalan), cast metal would no doubt be occasionally formed when the proportion of fuel to the burden of ore and flux in the charge was increased. On the other hand an increase in the burden would produce the pasty mass like that yielded by the Catalan forge, out of which malleable iron is hammered. "With such dimensions as these there would be no difficulty whatever, by proper treatment of the ores, in combining the metal with sufficient carbon to obtain a constant supply of cast iron; and there seems no doubt that by means of the Blauofen this was obtained in actual practice."† The theory of conversion of ore into cast iron in the high stack is thus briefly stated by Dr. Percy: "The temperature of the furnace, it is obvious, must increase in proportion to the depth from the top, and the reduced iron towards the lower and hottest part becomes carburised and converted into cast iron, which trickles down in a molten state to the bottom."‡ From the forge of two or three feet high, producing 1,200 or 1,500 lb. of wrought iron per week direct from the ore, to the blast furnace of 15 or 25 feet producing 12 to 15 tons of pig iron, there was a great advance. But with furnaces 70 to 85 feet high, producing 550 to 2,000 tons per week, and converting it as fast as made into steel, the advance is vastly greater; and it is the result for the most part of improvements made within the present century.

The manufacture of cast iron.

Smelting ore with charcoal fuel.

In the sixteenth century the large quantity of charcoal used in England for smelting iron ore excited alarm on account of the destruction of forests, and statutes were enacted to regulate the cutting of trees for this purpose within certain districts. In the reign of Elizabeth several acts were passed on the subject, one of which provided that no new iron works should be erected within 22 miles of London nor 14 miles of the Thames, nor in several parts of Sussex near the sea. Another prohibited the erection of any new iron works in Surrey, Kent and Sussex, and ordered that no timber of the size of one foot square at the stub should be used as fuel at any such works. The time had now arrived for means being taken to utilise mineral coal instead of charcoal; and although it had been in use for ordinary purposes

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and although the process of smelting varies in different districts, the variation is due partly to local custom and partly to the fact that the art has most advanced where the population is most dense and civilised.

* The date of the discovery of the process for making cast iron is unknown. Percy quotes a statement from Lower, the antiquarian, respecting a cast iron slab in Burwash church, Sussex, which would lead to the conclusion that cast iron was made in England five hundred years ago; he also quotes the same authority to show that the first cannons of cast iron were manufactured in Sussex in 1543. Sir Lowthian Bell is of opinion that the change in process has probably been affected within the last three centuries (Iron and Steel, p. 11); while Swank says cast iron guns were made near Erfurt in Thuringia in 1377, that in the fifteenth century pots, plates and balls of iron were cast at the Ilsenberg foundry in Germany, and that stoves are said to have been cast for the first time in 1490, in Alsace (History of the Manufacture of Iron in all Ages, p. 21).

† Sir Lowthian Bell's Manufacture of Iron and Steel, p. 11.

‡ Percy's Metallurgy of Iron and Steel, p. 349.

since the middle of the ninth century, if not earlier, it had never been successfully employed in the smelting of iron ore. Several experiments were made in the reign of James the First by Sturtevant, Rovenzon and others; but all had failed, with the one exception of Dud Dudley's. He has the credit of having first solved the problem, and although his process is not known it can hardly be doubted that the fuel was prepared by converting the coal into coke. He was strongly opposed by the iron masters, because he sold iron cheaper than they could afford to sell it;* the product of his furnaces (that of the largest being only seven tons of pig iron per week) was complained of as not merchantable, he was deprived of his works and inventions, he was ruined by lawsuits and riots, and when at the end of nearly forty years the king refused to renew his patent he gave up the struggle; but the knowledge of his invention died with him. In consequence of this failure the British iron trade gradually declined until about the middle of the eighteenth century it was not equal to the production of one modern blast furnace.† The iron manufacturers had to seek for supplies elsewhere, especially from Sweden and Russia, and although heavy duties were imposed the quantity brought in continued to increase.‡ The following figures of imports are given for periods between 1711 and 1766:

Dud Dudley's experiments with mineral fuel.

The British iron trade in the eighteenth century.

Years.	Tons.
1711 to 1718	15,642
1729 to 1735	25,501
1750 to 1755	34,072
1761 to 1766	48,980

It was during this critical period that final success was attained with mineral coal as a fuel for iron furnaces. About 1730 young Abraham Darby entered upon the management of his father's iron works at Coalbrookdale, and as the supply of charcoal was fast failing he attempted to smelt with a mixture of coal and charcoal, but did not succeed. Between that time and 1735, Percy

Success attained with mineral coal as furnace fuel.

*"Dudley sold his pig iron at £4 per ton and his bar iron at £12 per ton, the prices of charcoal pig iron and charcoal bar iron being at that time £6 or even £7 per ton, and from £15 to £18 respectively."—Percy's Metallurgy, p. 885.

† "In 1740 there were only 59 blast furnaces in work in England and Wales, the total make of which amounted to not more than 17,350 tons, being an average of 294 tons per annum for each furnace, a quantity very little exceeding that sometimes made in a single week in some of the furnaces in Wales at the present day." (Ure's Dictionary of Arts, vol. ii, p. 689). Arnold Toynbee says the quantity of iron imported into Great Britain at that time is computed at 20,000 tons. "In 1881 we exported 3,820,315 tons of iron and steel, valued at £27,590,908, and imported to the value of £3,705,332." (Industrial Revolution of the 18th Century in England, p. 49).

‡ In 1756 the British duty on imports of bar iron was £2 8s. 6d. sterling per ton and the Swedish export duties were £3 12s. 6d. A strong memorial was presented to the British Parliament in that year for the removal of the duties upon imports of bar iron from all countries, the same as had been done in 1751 upon bar iron imported from the colonies into the port of London and upon pig iron into other ports. The case of the manufacturers was based on the three following propositions, viz.: (1) That it is the interest of every manufacturing country to get as great a choice and variety of raw materials, and upon as cheap terms, as can possibly be procured. (2) That unless some commodities are taken from other countries by way of barter in the course of trade you can have but a small vent for your own manufactures, it being impossible for any nation to make all their payments in gold and silver, even if they abounded with the richest mines of those metals. (3) That cheapness in regard to price and goodness in regard to quality are the support and prop of all manufactures. See The Case in the Journal of the Iron and Steel Institute, 1887, No. 2.

relates, he determined to treat pit coal as his charcoal burners had treated wood. "He built a fire-proof hearth in the open air, piled upon it a circular mound of coal and covered it with clay and cinders, leaving access to just sufficient air to maintain slow combustion. Having thus made a good stock of coke, he proceeded to experiment upon it as a substitute for charcoal. He himself watched the filling of his furnace during six days and nights, having no regular sleep and taking his meals at the furnace top. On the sixth evening, after many disappointments, the experiment succeeded and the iron ran out well. He then fell asleep in the bridge house at the top of his old-fashioned furnace so soundly that his men could not wake him, and carried him sleeping to his house a quarter of a mile distant."* From that time his success was rapid, and in 1756 one of his furnaces, which produced 20 to 22 tons per week, was declared to be at a top pinnacle of prosperity. In 1888, about a century and a half from the time of Darby's discovery, the 424 furnaces of Great Britain in blast produced 7,998,969 gross tons of pig iron from 19,152,074 tons of ore, with 16,131,267 tons of coal;† and Sir Lowthian Bell is authority for the statement that the gas from the furnace now conducted to the boilers and hot-air stoves effects an annual saving of about 6,000,000 tons of coal on the pig iron product of that country alone.‡

Results of Darby's invention.

Abraham Darby increased the producing capacity of his furnaces by adding to the power of his machinery for driving the largest bellows which had then been made, but the old wooden or leather bellows soon gave place to the cylindrical cast iron bellows, invented by John Smeaton and set up first in 1760 at the Carron iron works in Scotland. These cylinders were four and a-half feet in diameter, exactly fitted with a piston which moved up and down by means of a water-wheel ; the air was admitted through a valve in the bottom when the piston rose, and when it fell the air was forced through a pipe into the furnace. Four of these cylinders were applied to blow the furnace, and the strokes of the piston being alternate an uninterrupted blast was produced. The furnace that produced ten or twelve tons weekly with the old bellows acquired a capacity with the improved bellows of forty tons ; and such was the impulse given to the trade by the new blast upon pit coal that in 1788 the pig iron product of England, Wales and Scotland was 68,300 tons, or 50,950 tons more than the product previous to the use of pit coal.

Invention of cylindrical bellows.

The invention of the steam engine by James Watt was also applied in the iron industry, in working mines and driving furnace machinery, and it no

The steam engine.

* Percy's Metallurgy of Iron and Steel, p. 888.

† Journal of the Iron and Steel Institute, 1889, No. 2, p. 486.

‡ The Reign of Queen Victoria, vol. ii, p. 214.

"In the middle of the eighteenth century a process for smelting iron with coal turned out to be effective; and the whole aspect of the iron trade was at once revolutionised. In fifty years the annual production of iron in Great Britain rose from under twenty thousand to more than one hundred and seventy thousand tons. During the fifty years that followed it rose to six millions of tons. Iron was to become the working material of the modern world; and it is its production of iron which more than all else has placed England at the head of industrial Europe." (Green's History of the English People, vol. iv, p. 280). "The iron industry had been equally [with cotton manufacture] revolutionised by the invention of smelting by pit coal brought into use between 1740 and 1750, and by the application in 1788 of the steam engine to blast furnaces. In the eight years which followed this latter date the amount of iron manufactured nearly doubled itself." (Toynbee's Industrial Revolution, p. 91).

longer became necessary to erect a furnace by the side of water-power. The proprietors of furnaces were enabled to largely increase their make, and fresh capital was embarked in the trade. Yet with such aids as pit coal, iron cylinders and the steam engine there were only 85 furnaces in blast in England, Wales and Scotland in 1788, producing scarcely 15½ tons each per week.

In the meantime other valuable improvements were being made in iron production—in the working of malleable iron and transforming cast or pig iron into wrought iron. In 1766 Thomas and George Cranage of Coalbrookdale procured a patent for the puddling of iron*, which is described in the specification as follows: "The pig iron is put into a reverberatory furnace, built of proper construction, and without the addition of anything more than common raw pit coal is converted into good malleable iron, and being taken red-hot from the reverberatory furnace to the forge hammer is drawn into bars of various shapes and sizes, according to the will of the workman." Another patent for puddling was taken out in 1783 by Peter Onions; but the inventor who made the process successful in general practice was unquestionably Henry Cort, who took out a patent in 1784. The whole process is described by Percy, who also records how Cort was wronged and ruined by the action of the government in consequence of a business arrangement entered into by him with one of its own officers. "He died in poverty," Percy says, "though he laid the foundation of the riches of many an iron master, and has largely contributed to the development of the resources and wealth of Great Britain."† Of the nature and value of Henry Cort's invention Sir Lowthian Bell says: "Cast iron, however valuable for being run into moulds, is useless where great strength and malleability are required. To obtain a material having these properties it is necessary to expel those substances which have entered into combination with the metal during the smelting of the ore. At first this separation was carried out in a Lancashire fire, as it is called, similar in dimensions and form to that used for obtaining malleable iron direct from the ore. In it the pig iron was melted with charcoal or coke, the combustion being maintained by a current of compressed air. After fusion the blast was continued, when, by its penetrating the molten iron, the carbon and most of the silicon and phosphorus were expelled, and the result was a spongy mass of wrought iron. The process is an expensive one in fuel, labor and waste of metal, but the product obtained was one of such quality that it continues to be the method employed for making the highly esteemed bars imported into this country from Russia and Sweden. Such was the method of obtaining wrought iron when Henry Cort, a native of England, invented the puddling furnace. In it the pig iron is melted, after which the workman stirs up the liquid metal to expose it to the action of the fire and of the oxide of iron which is always present. As the carbon, etc., are removed the malleable iron appears in the form of granules, which the puddler collects by means of his tools into four or five separate pieces known as puddled balls.

The puddling process.

Henry Cort's invention.

*Puddling is described by Percy as a process which consists essentially in stirring about pig iron molten on the bed of a reverberatory furnace, heated by flame until it becomes converted into malleable iron through the decarburising action of the oxygen of the air circulating through such a furnace.—Metallurgy of Iron and Steel, p. 627.

†Metallurgy of Iron and Steel, p. 629.

Each of these weighs about one hudredweight, and after being placed under a steam hammer it is rolled into a rough bar of different dimensions according to the purpose for which it is intended. Six charges, or thereabouts, constitute a day's work for two men, and the weight obtained is about 25 cwt., produced by the combustion of about the same quantity of coal. The puddling furnace, afterwards somewhat modified by S. B. Rodgers, continued from the latter part of the last to the middle of the present century to be the instrument by which practically all the malleable iron in the world was eventually made:"* In 1783 Cort had obtained a patent for grooved rolls, now called puddle rolls, by which the iron taken from the puddling furnace was drawn into bars of any shape, instead of being beaten out under the hammer. By this means the cost of labor in finishing iron was very greatly reduced, and it became possible to apply iron to purposes not thought of before Cort's time.

Grooved rolls for drawing puddled balls into bars.

These improvements were followed by marked economy in the smelting of ore, and the extended use of cast and wrought iron was accompanied by reductions in price. Within seven years of the introduction of puddling 50,000 tons of pig iron were annually converted into wrought or malleable iron in Great Britain by means of Cort's process.† The annual production was increased from 68,000 tons of pig iron in 1788 to 700,000 tons in 1828, being an increase from $15\frac{1}{2}$ to 35 tons per week for each furnace in blast. During the greater part of this period the industry was most generously protected by the customs' tariff of the country. Under Mr. Pitt's tariff of 1787 the duty on manufactured bar iron was £2 16s. 2d. per ton, and in 1819 it was £6 10s.; but by Huskisson's tariff in 1825 it was reduced to £1 10s. The iron masters were strongly opposed to this change, and made a vigorous protest against it. But Mr. Huskisson did not think it fitting that with an article like iron, in universal use in all manufactures, the people should suffer from scarcity, and he wondered that they should have submitted to have every article in which it is used greatly increased in price, as well as deteriorated perhaps in quality, in order to favor the British iron masters.‡ There was the less reason for the protest of the iron masters seeing that in no other country had the improvements and appliances introduced in Great Britain been employed to anything like the same extent in the manufacture of iron.

Results of Cort's inventions.

Customs' duties on bar iron.

Until 1828 all iron furnaces were worked with the cold blast, and it was a conviction of iron masters that the colder the blast the better. But in

*The Reign of Queen Victoria, vol. II, pp. 216-17.

†Referring to the results of Cort's inventions Prof. Leone Levi says when it became known that coals could be used instead of dear charcoal, and that the slow operation of the hammer could be altogether superseded so as to enable workers to produce a much greater quantity, and of a far superior quality, a new and unexpected impulse was given to the iron industry, with results far exceeding any anticipations. "In South Staffordshire in 1768 there was not a single furnace making charcoal iron, and only nine where pit coal was used, producing fifteen tons each per week ; while in all other parts of England there were twenty-four charcoal furnaces and forty-four pit coal furnaces. In very few years these multiplied enormously, production increased apace, and an immense industry sprang up as if by magic in hardware and locks, japanned goods and ironmongery."—History of British Commerce, 2nd edition, p. 10.

‡Levi's History of British Commerce, p. 168.

the year named James B. Neilson, manager of the Glasgow gas works, obtained a patent for the improved application of air "to produce heat in fires, furnaces and forges where bellows or other blowing apparatus are required." The blast was to be produced in the ordinary way, but was to pass into an air vessel sufficiently strong to endure it, and thence by a tube or pipe into the fire, forge or furnace. "The air vessel or receptacle must be air-tight, or nearly so, except the aperture for the admission and emission of the air; and at the commencement and during the continuance of the blast it must be kept artificially heated to a considerable temperature. It is better that the temperature be kept to a red heat, or nearly so; but so high a temperature is not absolutely necessary to produce a beneficial effect."* The advantages of this invention with respect to the economy of fuel were soon recognised, and in 1835 it was in use in almost every furnace in Scotland; but, like Dudley, Cort and others, Neilson was driven to defend his rights in the courts. In 1832 a license to use his invention was granted to the Messrs. Baird, proprietors of the Garthsherry iron works, in consideration of a royalty of one shilling per ton of the iron manufactured by them. Subsequently payment of this duty was withheld on various pleas, especially because of insufficient description and want of novelty, but also because the cold blast was more economical, although the defendants admitted that in ten years they had made a net profit of £260,000 on hot blast iron, and that in one year their profit was £54,000. The trial took place at Edinburgh in 1843, and Neilson's claim was fully established. The results obtained were from the outset eminently satisfactory, the same amount of fuel reducing three times as much iron, and the same amount of blast doing twice as much work as previously. The value of the invention thus disputed is now universally admitted, and the employment of the hot blast has been proved not only to be attended with a great economy of fuel, but to increase the productive power of the furnace also.† In 1828 the total make of pig iron in Scotland was not more than 30,000 tons, in 1839 it had increased to 200,000 tons, and in 1860 it had nearly touched 1,000,000 tons; but this increase was also due in part to the working of the rich Black-band ore near Glasgow. Taking account of other improvements effected in the process of reducing iron ore, such as use of the escaping gases of the furnace for making steam and hot air and increase in the height of the shaft and in the temperature of the blast, Sir Lowthian Bell makes the following comparisons: In 1835 furnaces 40 to 50 feet high and 5,000 cubic feet capacity, using cold blast, made 70 tons of iron weekly with 120 cwt. of raw coal per ton; in 1845, furnaces of the same height and capacity, with blast at 650° F., made 120 tons per week with 85 cwt. of coal per ton; in 1855 similar furnaces, with blast at 800° F. and using the escaping gas for steam and hot air, made 220 tons weekly with 62 cwt. of coal per ton; and in 1865 furnaces 80 feet high and capacity of 20,000 cubic feet, with blast at 1,000° F., made 550 tons of iron per week

The hot blast invention.

Neilson's right of invention contested.

Its practical results.

Economic comparisons.

*Specification of the patent, recorded March 3, 1828.

†Percy's Metallurgy of Iron and Steel, pp. 394-8, and Phillips' Elements of Metallurgy, p. 217.

with 40 cwt. of raw coal per ton.* The increase in the capacity of furnaces and in the temperature of the blast was introduced by the smelters of Middlesbrough, England, in 1863.†

Converting iron into steel by old and new processes.

The next and greatest invention in the history of the iron industry is Sir Henry Bessemer's process for converting iron into steel. Under the old process iron was converted into steel by being put into a large crucible or earthen pot, together with pulverised charcoal, and there heated for a considerable time by an external fire, the mouth of the crucible being closely stopt. This was the practice in England in 1750, when about 4,000 tons of Swedish iron were consumed for the purpose annually. The principles of the methods however depend on the quality of the iron to be converted, and are described by Dr. Percy as consisting of the addition of carbon to malleable iron, the partial decarbonisation of cast iron, and the addition of malleable iron to cast iron. Huntsman's process of making cast steel, Jeans says in his History of Steel, was perfected after a long series of experiments, commenced about 1740, and his was almost the only process followed on a large scale until overshadowed by the still more notable process of Bessemer. He took steps to bring its qualities under the notice of the Sheffield cutlers, but they "perversely declined to work with a metal so much harder and denser than any to which they had been accustomed."‡ He found a ready market for it however at Toledo in Spain, in France and over Europe. The invention was not patented, and the Sheffield cutlers sought to find out the method; Huntsman swore his workers to secrecy and carried on his manufacture only at night. In this he was successful for a time at least, but there is a tradition that the secret was at last stolen by a rival steel maker.§

Huntsman's process.

*Bell's Manufacture of Iron and Steel, p. 24.

†"By the increase in the temperature of the air, by utilising the waste gases and by increasing the size of the furnace the produce was raised from 200 to 500 or 600 tons per week, and the consumption of coal, all included, was reduced from three and three-quarters to two tons of coal per ton of iron. More recently the air has in some cases been heated in stoves of fire-brick to 1,200° or 1,500°, but the economy of fuel by this additional temperature has been small compared with that effected by Neilson, and after him by the Middlesbrough iron masters. On the other hand the weekly produce has been improved to the extent of 50 to 100 tons per week by the 200° to 500° in the heat of the blast. Where very rich ores are treated, as in the United States, as much as 60,000 tons a year, or even more than this quantity, has been run from one furnace, part of which extraordinary make is no doubt due to the use of this more highly heated air. The idea of utilising the combustible gas which escaped from the blast furnace is of French origin, dating so far back as 1814. It was however only when George Parry, in South Wales, simplified its application, about 1850, that its use began to become general."—Sir Lowthian Bell in vol. II of the Reign of Queen Victoria, p. 214.

‡Curiously enough, Sir Henry Bessemer has had the same experience of Sheffield, and with the object of introducing his steel he established small works there. Speaking on the subject at the May meeting of the Iron and Steel Institute in 1889 he said: "He was forced to do that from the fact that steel-makers by the old plan had no belief whatever in the possibility of making pig iron into steel in twenty minutes; and as he could not enforce the fact upon them it was necessary that he should compete with them in their own market; and that was the reason he established himself in Sheffield, wishing all the time that the Sheffield manufacturers could see things in the same light that he did; but they did not. For some considerable time his little works were going on, and it was not until they lowered the price of almost every article that they were producing some £10 or £20 below the then prices of Sheffield that Sheffield manufacturers began seriously to think that, after all, there was some little merit in what Bessemer was saying."—Journal of the Iron and Steel Institute, No. 1, 1889, p. 40.

§"This person, it is reported, presented himself in the garb of a beggar at the entrance to the Attercliffe works, under conditions most calculated to excite the sympathy of the workmen; it was during a dark winter's night, when the snow was falling fast, that this mean and skulking vagabond prayed for shelter and warmth in the casting house. The prayer was granted,—who could have refused it?—and at length the prize was secured. This may be a mythical story, or it may be absolutely true; many a time the same kind of artifice has been resorted to."—Percy's Metallurgy of Iron and Steel, p. 829.

Various modifications of Huntsman's invention were introduced from time to time, the most important of which appears to have consisted in the addition of manganese or carburet of manganese to the charge of blister steel in the crucibles. This was the invention of Josiah Marshall Heath, for which he obtained a patent in 1839, and by his process manufacturers were enabled to make a malleable cast steel from low-priced British bar iron, instead of using as previously for the purpose the high-priced bar iron imported from Sweden and Russia. Soon afterwards Heath found that a mixture of oxide of manganese and carbonaceous matter could be substituted for the so-called carburet of manganese, and he granted licenses to certain steel-makers in Sheffield and undertook to supply them with manganese in a suitable state for application. Instead however of furnishing the substance described in the specification of the patent, he furnished the new unpatented mixture. "A person of the name of Unwin," Percy relates, "was employed by Heath as an agent for conducting the commercial part of the business, and very soon this person started as cast-steel maker on his own account, using the mixture of manganese instead of the carburet and denying that he had thereby infringed Heath's patent. Several steel-makers at Sheffield combined with Unwin, and provided a common fund wherewith to contest Heath's claim to the application of the mixture. Costly and protracted litigation was the result, and the opponents of Heath finally triumphed over Heath's widow in an appeal to the house of lords."* It is Percy's opinion, after reading all the evidence in the case, that if any man ever deserved a patent Heath was that man; and although his process effected a saving of forty to fifty per cent. on the cost of steel to the manufacturers, conferring commercial profits to be reckoned by millions, the steel-makers of Sheffield used the money which his process had enabled them to earn in carrying on a fifteen years' litigation against him on a technical plea (the process adopted being chemically equivalent to the one described in the patent), and finally secured a verdict in the house of lords, although of the eleven judges who delivered their opinion to that house seven were in favor of the claim of Mr. Heath.†

Modification Huntsman's invention.

Heath's process.

Despoiled of his patent right.

But Bessemer's invention has overshadowed all others. His process was first publicly announced in a paper read before the British Association in 1856, under the title of 'The Manufacture of Iron and Steel without Fuel.'‡ It was heard without a word of comment, and was published in the proceedings by title only. There were not wanting men of experience and scientific attainments, Jeans says, who ridiculed and denied the possibility of producing iron and steel without fuel; and others again, wise after the event, suddenly discovered that Bessemer's was quite an ancient process, and had been before the world and proved to be valueless during many years. "The

Bessemer's invention.

*Metallurgy of Iron and Steel, p. 841.

†David Mushet calculates that Heath's invention for making steel caused an immediate reduction of £30 to £40 in the price of good steel, and resulted in an aggregate saving of not less than £2,000,000 from 1839 to 1855, besides rendering England comparatively independent of Swedish and Russian iron, previously imported in large quantities.—Jean's History of Steel, p. 30.

‡"Anything more erroneous than its title cannot well be conceived. The pig iron to be converted is both smelted with fuel and again melted with fuel before it is treated by Mr. Bessemer."—Percy's Metallurgy of Iron and Steel, p. 815.

savants of the British Association were so dumbfounded by Bessemer's iconoclastic ideas that they did not attempt to disscuss his paper."* The first patent was taken out October 17, 1855, and the invention was described as consisting of forcing currents of air or steam, or both, into and among particles of molten iron. Steam, it was stated, cools the metal, but air causes a rapid increase in its temperature, and it passes from a red to an intense white heat. Another patent was obtained in December of the same year, and a third on February 12th, 1856. Molten crude iron, or remelted pig or finery iron, the third patent claimed, is converted into steel or malleable iron "without the use of fuel for reheating or continuing to heat the crude molten metal, such conversion being effected by forcing into and among the particles of a mass of molten iron currents of air or gaseous matter containing or capable of evolving sufficient oxygen to keep up the combustion of the carbon contained in the iron till the conversion is accomplished." It is under this specification, with the non-use of steam and other modifications introduced since, that the process is carried on at the present time. "The main point of my invention," Mr. Bessemer has elsewhere said, "is the forcing of atmospheric air upwards through fluid iron." The heat is obtained by the combustion of the carbon and silicon which had united themselves with the iron in the blast furnace, and the temperature rises to a pitch which maintains even malleable iron in a liquid state.† In describing the process as carried on in a test experiment towards the end of 1856 Percy confesses that he never witnessed any metallurgical process more startling or impressive. "After the blast was turned on all proceeded quietly for a time, when a volcano-like eruption of flame and sparks suddenly occurred, and bright red hot scoriæ or cinders were forcibly ejected, which would have inflicted serious injury on any unhappy bystanders whom they might perchance have struck. After a few minutes all was again tranquil, and the molten malleable iron was tapped off."‡ This appearance of a Bessemer converter at work will be familiar to anyone who has witnessed the operation. But for a time the process only seemed capable of giving brilliant exhibitions, excepting when Swedish iron of great purity was employed in the charge. The ordinary run of British iron was entirely unsuited for treatment in the converter, and for the use of brands which contained more than one-thousandth part of their weight of phosphorus it seemed to be hopeless, since this substance is not reduced in the process of conversion to any sensible degree. But by an invention of Robert F. Mushet, dated September 22, 1856, the phosphorus difficulty was overcome very largely by the addition of molten spiegel iron to the decarburised metal in the converter while in its liquid state, by which the proportion of carbon necessary to make steel is restored; this means however is only successful with iron containing not more than

The Bessemer patents.

The process described.

[T]he phosphorus [d]ifficulty.

*So says Jeans, but it ought to be said that the paper was read before the Mechanical section of the Association. Had it been read before the Chemical section it would almost certainly have met with a different reception.

† "The melting point of wrought iron is so high that it is only within the last quarter of a century that we have been able to bring any quantity, beyond a few pounds, to the fluid state at one time by means of heat."—Bell's Manufacture of Iron and Steel, p. 381.

‡ Metallurgy of Iron and Steel, p. 815.

the thousandth of one per cent. of phosphorus. For thirty years almost all the iron converted into steel by this process in Great Britain was the product of Spanish ores brought a thousand miles across the sea; but by the joint efforts of such metallurgists as Thomas, Gilchrist, Snelus, Martin, Siemens and others the evil has been successfully dealt with by the basic process, in which during the act of conversion the phosphorus is transferred to the slag by means of lime, so that British pig iron containing 1 to $1\frac{3}{4}$ per cent. of phosphorus is now fitted for use in the Bessemer converter.*

The basic process for eliminating phosphorus.

But a service of hardly less importance to the iron and steel industry has been rendered by Sir Henry Bessemer along another line, viz., the machinery by which the process is carried on. "The purely engineering feats accomplished by him in the development of his invention were essential to its success," Mr. Swank says, "and they amaze us by their novelty and magnitude. Those who have never seen this machinery in operation can form but a faint idea of its exquisite adaptation to the purposes to be accomplished. A Bessemer converter, weighing with its contents from twenty to thirty tons, is moved at will on its axis by the touch of a man or boy, and receives in response to the same touch a blast so powerful that every particle of its many tons of metallic contents is heated to the highest temperature ever known in the mechanic arts. The honor of inventing this machinery is all Mr. Bessemer's own."† In the Edgar Thomson works near Pittsburg the writer has witnessed the conversion of fifteen tons of iron into Bessemer steel in twenty minutes; in ten minutes more it was cast into ingots, and these were hoisted by powerful cranes from the pit to cars and taken to the rolling mills, where they were removed from the iron moulds by hydraulic pressure, and with one reheating each ingot was rolled into a rail ninety feet long,—thus completing the whole operation of change from molten iron to steel rails within the space of one hour.‡ And so cheaply is the operation accomplished that steel rails have almost entirely taken the place of iron rails.§ Indeed, thanks to the Bessemer process, steel is now being employed for almost every purpose for which iron was previously used.

Labor-saving machinery for Bessemer converters.

The Edgar Thomson works.

In 1854 the whole steel trade of Great Britain was only 40,000 tons, and it was then selling at £50, £60 and £70 per ton, and two or three years later

* Sir Lowthian Bell in the Reign of Queen Victoria, vol. II, p. 221.

† History of the Manufacture of Iron in all Ages, p. 303.

‡ Concerning other machinery employed in iron and steel works Sir Lowthian Bell says: "Fifty years ago the largest iron boiler plates which could be rolled measured 9 feet by 3 feet, and weighed 5 to 7 cwt. Now iron of this description is turned out 13 feet by 10 feet, weighing 15 to 18 cwt. Still more striking is the present power of producing armour-plates for protecting the sides of our war steamers. These are made as large as the thin plates just mentioned, but instead of about three-eighths of an inch they measure 19 inches in thickness and weigh when finished 43 tons. To manufacture such plates as these, furnaces to heat masses of metal, machinery to move them to the rolling-mill and rolls to extend them have to be sufficiently powerful to deal with 54 tons, which is the weight of the rough block of iron or steel required to give a finished armour plate of 43 tons." (The Reign of Queen Victoria, vol. II, p. 223). In his address as president of the Iron and Steel Institute in May, 1889, Sir James Kitson gave an instance of a plate rolled by Cammell & Co. of Sheffield which weighed 65 tons. At the Consett iron works, he said, the output is 1,000 tons of plates per week steadily, whereas twenty-five years ago it was considered very good work to turn out 250 tons in one week. (Journal, No. 1, pp. 17-20).

§ In the early days of railway construction the best iron rails were about 15 feet long and weighed about 250 lb. Now a steel rail 90 feet long and weighing 2,460 lb. can be finished with not more than half the men required to make the old rail of 250 lb., and length and strength and weight imply increased safety in the running of trains, as well as prolonged life for the rail itself.

Growth of the steel trade and the fall of prices.

railway wheel tires were selling at £90 per ton. The first steel rails, made in 1861, sold at £23 per ton, and in 1870 steel railway bars were sold at £11 to £12 per ton, while steel plates which formerly sold at £50 to £60 per ton were sold in that year at £18. In 1888 the total production of Bessemer steel ingots in Great Britain was 2,012,794 gross tons, of open hearth steel ingots 1,292,742 tons, and of basic steel 408,594 tons, or a total of 3,714,130 tons; while the production of Bessemer steel rails was 979,083 tons, which sold at prices ranging about £4 per ton, or £3 per ton less than the average selling price of iron during the forty years preceding Neilson's invention of the hot air blast.* The Siemens and Siemens-Martin open hearth processes, which stand next in point of success to the Bessemer, are equally deserving of mention with it†; but the facts already presented amply justify the conclusion that the great progress made in the iron industry of the world during the last hundred years has been due in very large part, if not wholly, to the service of invention. Without the contributions of skill and science the state of that industry in Europe and America might still be what it is in the heart of Africa.‡

* In the United States 1,552,631 net tons of Bessemer and 5,261 tons of open hearth steel rails were produced in 1888, while the total quantity of iron rails was only 14,252 tons. In the previous year the total quantity of steel rails made in that country was 2,373,335 tons, against 23,062 tons of iron rails. Prices in 1888 at the Pennsylvania mills ranged from $27.50 to $31.50 per gross ton. In 1867 the average price was $170, in 1872 $112, in 1877 $45.50, in 1882 $48.50; in 1884 it fell to $31.75.

† In the opinion of some authorities the open hearth process is believed to produce a material more perfectly uniform in its character than the Bessemer process, and for this reason open hearth steel was selected for the construction of the great bridge crossing the frith of Forth.

‡ Professor Leone Levi's testimony of the service of invention to iron-making is very emphatic. He says: "In 1788 the iron make of Great Britain was only 68,000 tons per annum. But immense improvements have been introduced since then. By opening new localities, by reducing the expense of fuel, by employing the cheapest material, by utilising the gases and waste heat of the blast and puddling furnaces, by modifying the character of the furnaces, by economising the wasteful processes of refining, and above all by substituting mechanical for human labor, the production of iron increased enormously, and in 1878 it reached 6,381,000 tons per annum of pig iron, representing a value of £16,155,000, whilst if we take the manufactured iron in bar, sheet and rails the value would be double or treble that amount." (History of British Commerce, 2nd ed., p. 532). The consequence of the inventions introduced by Mushet, Krupp, Bessemer, Siemens, Whitworth and many others, Professor Levi adds, has been a large reduction in the price of steel. "Twenty-five years ago the price of cast steel tires was 120s. per cwt., it is now (1880) from 18s. to 25s. per cwt. The price of forged steel cranked axles was, when first introduced, £15 per cwt., it is now 65s. to 70s. per cwt. The price of straight axles and shafts was from 40s. to 50s. per cwt., it is now from 19s. 6d. to 23s. per cwt." (p. 533).

James M. Swank, secretary of the American Iron and Steel Association, also says: "During the latter part of the eighteenth century and the whole of the nineteenth century down to the present time no other country has occupied so conspicuous a position in the manufacture of iron and steel as Great Britain. Spain and Germany had in turn been more prominent in the production of these essentials of civilisation, but Great Britain spurned all rivalry when she began to make pig iron with the aid of mineral fuel and her powerful blowing engines. She had abundance of iron ores and mineral coal, and her people had applied to the utilisation of these products their invincible energy and their newly-developed inventive genius. France, Germany and other continental countries might have substituted mineral coal for charcoal, invented the puddling furnace or perfected the rolling mill and the steam engine, but none of them did. To England and Scotland is the world indebted for the inventions that gave a fresh impetus to the manufacture of iron in the eighteenth century; Huntsman, Darby, Smeaton and Cort were Englishmen, and Watt was a Scotchman; and it is also indebted to the same countries for most of the inventions of the present century, which have further developed the manufacture of iron and increased the demand for it, and which have almost created the manufacture of steel. Stephenson, the Englishman, improved the locomotive in 1815, and in 1825 the first passenger railroad in the world was opened in England, Stephenson's locomotive hauling the trains. Neilson, the Scotchman, invented the hot blast in 1828; Crane, the Englishman, applied it to the manufacture of pig iron with anthracite coal in 1837; Nasmyth, the Scotchman, invented the steam hammer in 1838 and the pile-driver in 1843; and Bessemer, the Englishman, invented in 1855 the process which bears his name and is the flower of all metallurgical achievements,—a share in the honor of this invention

FUTURE OF THE IRON INDUSTRY.

In the century and a half following the discovery of Abraham Darby's process of preparing mineral coal for furnace fuel, during which the annual production of pig iron in Great Britain rose from 17,350 tons to very nearly 8,000,000 tons, the growth of the industry is from first to last the story of the triumphs of man over matter. Without the aid of invention iron-making in that country could hardly have survived the middle of the eighteenth century, while with its aid she has been enabled, until very recently, to produce four times more iron every year than all the world besides. Yet the use of those inventions has been as free and open to iron-workers in all other countries as to the citizens of Great Britain, and not even there have they been more promptly seized upon than by the iron masters and manufacturers of the United States. And if the industry is ever to be built up in Canada our greatest reliance must be upon an intimate knowledge of methods and processes. "Let us develop our appliances and improve our processes with care, prudence and wisdom," Sir James Kitson counsels the British iron men, "then will our progress be sound and secure." This is more necessary in Canada even than in Great Britain, seeing that one of our great lacks is in men of skill and experience to engage in and carry on the work. In one particular we have an advantage; it will not be necessary to replace one set of costly appliances by another, as iron-workers in Great Britain and the United States have been obliged to do very extensively during the last thirty years, to the great loss of capital employed in the business. We may begin with the best appliances, and with skill and capital we can start upon even

Progress by the aid of invention.

Canada's requirements, and the necessity of beginning right.

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however being fairly due to the co-operating genius of Robert F. Mushet, also an Englishman but of Scotch parentage. The Siemens' regenerative gas furnace, which has been so extensively used in the manufacture of iron and steel, is also an English invention, although the inventors, Sir William and Frederick Siemens, while citizens of England, were natives of Hanover in Germany."—Iron in all Ages, p. 46.

"I must ask you to transport yourselves in imagination to England as it was a century and a quarter ago. We are accustomed to think that, however the life of man may alter, the earth on which he moves must remain the same. But here the revolutions in man's life have stamped themselves upon the face of nature. The great landmarks, the mountain ranges, the river channels, the inlets and estuaries, are for the most part unaltered; nothing else remains the same. For desolate moors and fens, for vast tracts of unenclosed pasturage and masses of woodland, we have now corn-fields and orchards, and crowded cities with their canopies of smoke. Only a few years before the time of which I speak, men complained that half the country was waste. Today we have a struggle to preserve any open land at all. It is to a revolution in three industries, agriculture, cotton and iron, that this transformation is principally due. . . The iron industry, with which the material greatness of England has during the present century been so conspicuously associated, was gradually dying out. Much of the ore was still smelted by charcoal in small furnaces blown by leather bellows worked by oxen. And it was not a trade upon which the nation looked with complacency or pride. On the contrary, it had long been denounced by patriots as the voracious ravager of the woods which furnished timber for our warships, and pamphleteers demanded that we should import all our iron from America where vast forests still remained to be cleared in the interests of agriculture. Not cotton and iron, but wool was considered in those days the great pillar of national prosperity."—Toynbee's Industrial Revolution, pp. 179-81.

"Not only has nearly every important machine and process employed in manufactures been either invented or perfected in this country in the past, but it is not too much to say that most of the prominent new industrial departures of modern times are due to the inventive power and skill of our countrymen. Amongst these are the great invention of Bessemer for the production of steel in enormous quantities, by which alone, or with its modification by Thomas and Gilchrist, enabling the commonest description of iron to be used for the purpose, steel is now obtained at one-tenth the price of twenty years ago. . . In the manufacture of iron and steel we stand preeminent, and we are practically the naval architects of the world. Our technical journals, such as those of the Institutes of Civil and Mechanical Engineers and of the Iron and Steel Institute, are industriously searched and their contents assimilated abroad." -Second Report of the Royal Commissioners on Technical Instruction (1884) vol. I, pp. 506-7.

terms with the iron men of the United States and Great Britain. But we must begin right—with skilled management, the best and most economic appliances, a sufficiency of capital, and not unmindful of the wants of the home market or our trade relations with other countries.

The world's requirements as contemplated by Percy and Jeans.

The future of the industry is hardly in doubt; the world is yet far from having reached the limits of its requirements, and for many years to come in Canada, the United States, South America, Australia and Asia the demand for iron products will continue to increase in volume. Writing on this feature of the subject in 1864 Dr. Percy said: "Notwithstanding the marvellous development of the iron trade in this and other countries since the introduction of railways, yet it may be safely affirmed that the uses of iron will be vastly more extended than at present, and that there is no just ground for apprehension lest there should be over-production of this precious metal. Even the railway system is in a state of rapid growth, and the time will come when every habitable part of the earth's surface will be reticulated with iron or steel roads. The day of steel has arrived—but not to the exclusion either of wrought or cast iron; and steel is destined to exercise an important influence on the destinies of the human race."* But Dr. Percy saw only through a glass darkly, as evidenced by his reference to the coming time of iron rails headed with steel. Rails of this class were hardly more than introduced when they gave place to the all-steel rail; and even now steel ships are beginning to take the place of iron and wooden ones on the waters of our great lakes.† Jeans in concluding his History of Steel says: "The more the subject of the applications of steel is inquired into, the more does it seem incapable of exhaustion. Great things have been accomplished in the past, but much yet remains in the future. The manufacture of steel is far from finality. Even now some of the leading steel works in France are assaying the production of ingots 100 tons weight. Steel indeed may be compared in reference to its multifarious uses with the elephant's trunk, the adaptability of which enables it with ease to pick up a needle or to pull up a tree. High authorities have expressed the opinion that steel will have the future nearly altogether to itself, displacing copper for fire boxes, etc, silver for articles of ornament and lead for purposes of softness, as much as it is superseding iron in respect of utility, economy and endurance. And as it is difficult to set bounds to the ultimate applications of steel, so is it impossible to limit the means of its production. Recent metallurgical progress has indefinitely increased the resources available for the latter purpose. Science has at last found a method of ridding of their deleterious contents the ores of iron heretofore unsuited for the manufacture of steel, and henceforth if metallurgists of experience are not greatly deceiving themselves the cheapest and the most plentiful ores will, by one of the greatest chemical triumphs of the age, be raised to the same rank as the richer and comparatively limited ores that have alone been deemed fit for the manufacture of steel until now.‡

* Metallurgy of Iron and Steel, p. 890.

†To James Riley, manager of the Glasgow steel works, is due the credit of first using mild steel in the construction of ships, he having built two steel vessels in 1875.

‡ This was written in 1880.

The horizon of the future therefore is not bounded by any limitation of the supplies of raw material. Nor is it any more likely to be measured by the uses of steel, for they are multiplying every day, and as the manufacture is cheapened and improved so will the applications continue to increase. In the track of this movement many changes must follow, and have even already occurred, of which we have been able to take but scant cognizance. The hard and irksome work of the puddler has been superseded by less arduous, and in the main by less skilled labor.* One of our greatest authorities has calculated that to convert fluid cast iron into steel the labor required is only about one-third of that required to convert pig metal into wrought iron, while the fuel consumed is only about one-fourth that formerly used. The economy of coal is therefore another important corollary of the advance of steel, and this economy, great though it be in the aggregate, is trifling in comparison with that accomplished through the greater strength and endurance of that which we are fully justified in describing as the metal of the future." Fifty years ago the world's production of iron was about 2,750,000 tons, Great Britain being credited with 1,120,000 and the United States with 300,000 tons, and in 1888 it had increased to nearly 23,200,000 tons, of which Great Britain produced in round numbers 8,000,000 and the United States 6,500,000 tons. In 1837 the consumption per capita in the British islands was about 78 lb. and in 1887 it was reckoned to be 300 lb. In the United States it increased from about 95 lb. in 1860 to 270 lb. in 1880 and probably to 300 lb. in 1888.† The consumption of Canada in 1888 did not exceed 100 lb. per capita; yet that is nearly as large as the average for Europe and the United States, and more than double the consumption of the South American states. It is a safe prediction that in less than fifty years the present per capita consumption of iron in the world will be 50 lb., and that the requirements of the United States and Canada alone will be 20,000,000 tons yearly. Iron ore does not grow like forests or grain crops, and every year the world's supply is being reduced by the quantity raised and smelted. Here in Ontario our deposits are for the most part as they came from the hand of nature, and they are believed to be of enormous extent. If we have skill and enterprise and capital we may develop them; we may build up an industry of immense value; we may even take rank as iron manufacturers with our kinsmen across the lakes and beyond the sea.‡

Past, present and future.

* Few puddlers are able to continue the work after the age of 45 or 50 years.

† In speaking before the Iron and Steel Institute in May, 1887, Sir Lowthian Bell said: "The United Kingdom consumed, after deducting the iron exported, about 299 lb. per annum per head of its population. The United States followed with 270 lb. But the 319 millions of inhabitants of all Europe and the United States of America only consumed 107 lb., some countries only requiring about 24 lb.; and the average consumption of the 1,425 millions of people who inhabited the globe was only about 32 lb., or about one-ninth of what was used in the United Kingdom and the United States together. Still more striking was the fact that there were 1,014 millions who used less than 2 lb. of iron per annum, and of these there were 517 millions who managed to exist with a consumption of less than a ½ lb. per individual per annum."—Journal of the Institute, No. 1, 1887, p. 120.

‡ As evidence of the importance of the iron and steel industry in giving employment to workingmen, the following extract is taken from the Pittsburg Dispatch of December, 1888, showing the aggregates of semi-monthly pay-rolls in the iron and steel mills of that city and its suburbs: "Commencing with Carnegie Brothers & Co. and Carnegie, Phipps & Co.: They employ about 6,000 men, and pay out every two weeks as follows: At the two Lucy blast furnaces, $8,000; at the Union Mill, Thirty-third street, $30,000; at the Union Iron and Forge Mill, Twenty-ninth street, $25,000; at the Bessemer Steel Mill, Homestead,

COPPER AND NICKEL SMELTING.

Treatment of ores carrying compounds of copper and nickel.

The discoveries of extensive ranges of copper and nickel ore in the district lying northward of Georgian bay, and especially the mining and smelting operations carried on in the vicinity of Sudbury, demand notice in this Section of the report. The combination of metals in the ore of those ranges however is so peculiar that it is yet too early to speak with confidence of the success of works erected to reduce it upon an extensive scale. "This combination of nickel and copper," as stated by Dr. Peters in his evidence, "has not been met with before in such quantities as to require separation in a wholesale way. The only case of the kind in America is the Gap mine in Pennsylvania, and there they use the old European way of dissolving in acids, which would never do in our case." At present prices the copper contents of the ore are only of secondary importance, even assuming that the separation of the metals from other combinations and from each other can be accomplished satisfactorily and by an economic method. It is claimed that such a process has been discovered at the smelting and refining works of Sir Henry Hussey Vivian at Swansea in Wales, where experiments with the ore and matte have been carried on for some time; and if it be true, as reported, that this distinguished metallurgist intends to establish reducing works at Sudbury to smelt the ore of a mineral property he has recently acquired

$22,000, and at the Edgar Thompson Steel Mill and seven blast furnaces, Braddock, $70,000; making a total for the Carnegie firms alone of $155,000. Next is the National Tube Works, at McKeesport. They operate three rolling mills and the largest pipe mill in the world. They employ 5,000 men and pay out $125,000. Oliver Brothers & Phillips rank at the head of the third class in paying out money. This firm operates three iron mills and a steel plant, and gives work to about 3,000 men, paying them $75,000. Jones & Laughlins, operating the American Iron Works, give work to 3,000 men and their pay roll amounts to $75,000, but only from $45,000 to $55,000 is said to be paid out in money, the remainder being taken from the company's store. The Pittsburg Forge and Iron Works gives work to 700 men and pays out $13,000; the Pittsburg Iron Works of J. Painter & Sons, 900 men, $25,000; Park Bros. & Co,, Black Diamond Steel Works, 1,200 men, $31,000; the Pittsburg Steel and Casting Company, 300 men, $7,500; the Clinton mill and blast furnace, on the south side, 550 men, $12,500; A. M. Byers & Co.'s Iron and Pipe Mill, 550 men, $14,500; Anchor, Nail and Tack Works, Chess, Cook & Co., 400 men, $11,000; Sligo Iron Mill, Phillips, Nimick & Co., 550 men, $13,000; Sheffield Steel Works, Singer, Nimick & Co., 700 men, $15,500; Glendon Spike Works, Dilworth, Porter & Co., $12,500; Republic Iron Works, 600 men, $14,500; Elba Iron and Continental Tube Company, at Frankstown, 650 men, $15,000 (the tube mill is at present idle). The Soho Iron and Steel Mill and the blast furnace of Moorhead, McCleane & Co., 700 men, $15,600; Keystone Rolling Mill, 400 men, $10,000; the Star Iron Mill of Lindsay & McCutcheon, 550 men, $13,500: the La Belle Steel Mill, 250 men, $8,000; the Kensington Iron Mill of Lloyd, Sons & Co., 250 men, $7,000; the Wayne Iron and Steel Mill of Brown and Co., 550 men, $14,000; the Juniata Iron and Steel Mill and two blast furnaces of Shoenberger & Co., 750 men, $20,000; the steel works of Howe, Brown & Co., 650 men, $18,000; the Sable Iron Works of Zug & Co., 500 men, $14,000; the Millvale Mill of Graff, Bennett & Co. (which is at present shut down), 675 men, $16,500; the Solar Iron Works of Wm. Clark & Co., 450 men, $9,000. The Fort Pitt Iron Works, when last operated by Graff, Bennett & Co., gave work to 600 men, who were paid $50,000; the Vesuvius Iron Mill of Moorhead Bros. & Co., 450 men, $9,000; the Etna Iron and Pipe Mills of Spang, Chalfant & Co., 650 men, with a pay roll of $16,000 (but seldom more than $11,000 is paid out in cash, the rest being taken out of the company's store); the Spang Steel and Iron Company, 350 men, $8,000; the Crescent Steel Works of Miller, Metcalf, Parkin & Co., 500 men, $15,000. This latter plant is one of the leading steel mills in the world. The finest grade of steel is made there, which is used for making fine light shears, needles and clock spring steel. The Linden Steel Mill, 400 men, $12,000; the Oliver & Roberts Wire Mill, 400 men, $10,000; the Soho Pipe Mill, 300 men, $8,000; the Pennsylvania Tube Works, 700 men, $16,000; the Isabella Furnace Company, 350 men, $8,500; the Edith Furnace Company, 150 men, $4,000; the Carrie Furnace Company, 150 men, $4,000; the Eliza Furnace Company, 475 men, $9,500; the Braddock Wire Works, 250 men, $7,500; the Chartiers Iron and Steel Company, 200 men, $7,000; the Vulcan Forge and Iron Works at Chartiers, 400 men, $9,000; the Pittsburgh Steel Works at Chartiers, 400 men, $9,000, and the McKeesport Iron Works of W. D. Wood & Co., 450 men, $11,000." That makes a total of $939,500 every two weeks. In one year of twenty-five pay days per month, it would amount to $23,487,500 paid out to 37,350 men who are employed in the manufacture of iron and steel alone.

there, it may be assumed that his experiments have been attended with success, or at any rate that the progress in treatment justifies the expectation of success.

IMPORTANCE OF THE INDUSTRY.

The value of such works to our province, if established and carried on at paying figures, must appear obvious when it is seen how large the industry is elsewhere as limited to production of ingot copper alone. The following table, published in the report on the Mineral Resources of the United States for 1887, gives the copper production of the world in long tons for the eight years 1880-7 :

The copper production of the world.

Countries.	1887.	1886.	1885.	1884.	1883.	1882.	1881.	1880.
Europe..........	79,244	75,234	74,839	73,959	72,172	66,786	65,006	59,370
North America ..	85,398	73,386	77,706	64,750	54,171	42,868	34,551	28,950
South America...	33,570	40,088	44,573	48,269	47,485	51,108	44,389	47,616
Africa	7,400	6,125	5,700	5,260	6,575	6,316	4,067	5,239
Asia.....	11,000	10,000	10,000	10,000	7,600	4,800	3,900	3,900
Australia......	7,700	9,700	11,400	14,100	12,271	8,512	10,000	9,700
Totals.........	224,312	214,533	224,218	216,338	200,774	180,390	161,913	154,775

This is an increase of 69,537 tons in seven years, but as prices were maintained at a high rate during the greater part of the time by the operations of the French copper syndicate the increase may be regarded as abnormal. The total product of the United States in 1879, according to the census, was 56,115,354 lb. ingot copper, of which 45,830,262 lb. was credited to the mines of northern Michigan. The capital employed in the industry in Michigan as reported in the census was $30,413,551, of which $24,116,366 was the value of real estate, $5,275,185 the value of plant and $1,022,000 the amount of working capital. The total number of employés in the census year was 5,004, made up of 2,076 miners, 2,742 laborers and 186 officers of the administrative force, and the amount of wages paid in the year was $2,661,243. The value of materials or supplies used was $1,215,206, and the value of the product was $7,979,232.* In 1887 the total product of the United States was 180,920,524 lb. and that of northern Michigan 75,471,890 lb., the average selling price of which was about 11½ cents per pound. The copper production of Great Britain has fallen from 15,968 long tons in 1860 to not more than 1,500 tons in 1887. In Chili also the output appears to be falling off in recent years, the exports from that country having been 25,498 tons in 1857, 44,654 tons in 1867, 45,400 tons in 1877 and 29,150 tons in 1887. In Spain and Portugal however production is on the increase, the total for 1881 having been 32,697 tons in 1879 and 52,219 in 1887. At the famous Rio Tinto mine in Spain the ore occurs in large masses very similar to that of the Sudbury ranges, saving that it contains no nickel; it is a low grade of copper pyrites. One of the veins is 8,000 feet long by 180 wide and another three-fifths of a mile long by 600 feet wide, and it is computed that there are

Production of copper in northern Michigan.

Production in other countries.

Famous Spanish mines of copper.

*United States Census of 1880, vol. xv, pp. 798-800.

150,000,000 tons of ore in sight. It is worked by an English company which has a paid-up capital of £3,250,000 stg., and the total cost of the mine as shown by the annual report for the year ending December, 1888, was £3,331,095. The report for that year shows that the profits on sales of produce realised £1,142,777, and after providing for payment of interest, expenses of administration, bonds redeemed, plant, repairs, etc., there remained available for dividend a net profit of £754,706. The quality of the ore will appear by the following table, giving the quantity raised from the mine for shipment and local treatment in the seven years 1882-8, together with the average copper contents of the ore :

Year.	For shipment.	For local treatment.	Total.	Copper contents.
	tons.	tons.	tons.	per cent.
1882	259,924	688,307	948,231	2.805
1883	313,291	786,682	1,099,973	2.956
1884	312,028	1,057,890	1,369,918	3.234
1885	406,772	944,694	1,351,466	3.102
1886	336,548	1,041,833	1,378,381	3.046
1887	362,796	819,642	1,182,438	3.047
1888	434,316	969,317	1,403,633	2.949

Ancient mines which pay large dividends.

It will be shown farther on that the copper contents of the Sudbury mines are twice as great as those of the Rio Tinto, besides their contents of nickel. The Rio Tinto and Tharsis mines in Spain are of great antiquity. Sir Hussey Vivian says there is good reason to believe that they were worked by the Romans,* and in the opinion of some people the Tharsis mine is the Tarshish of Solomon's day. Yet those mines, ancient as they are and long-worked though they have been, are still yielding immense profits to their owners, as the following payments of dividend show :

Year.	Rio Tinto.		Tharsis.	
	Dividend.	Rate p. c.	Dividend.	Rate p. c.
1886	$ 487,500	3	$ 440,449	7½
1887	1,625,000	10	587,660	10
1888	2,762,500	17	1,173,200	20

NOTE.—A balance of £202,206 was carried forward in revenue account after paying the large dividend of the Rio Tinto company in 1888.

*"Last year (1879) I visited the famous Rio Tinto and Tharsis mines and found them covered with mountains of old slags, just as the often prophesied New Zealander may some day wander over and wonder at our Swansea slag-heaps. There is good reason to believe that these workings were Roman, and no one looking at those heaps can doubt the great scale upon which they worked and the skill with which their operations both below and above ground were conducted. They rejected and left unworked the low-produce pyrites, but they followed eagerly the rich veins of yellow ore which traverse those mighty deposits. I saw the wonderful northern face of the great Open Cast at Rio Tinto, compact pyrites some 80 or 100 feet deep and 1,000 feet long, pierced at frequent intervals by ancient Roman galleries, following with true mining instinct the veins of rich ore. I examined critically the slag-heaps, and was astonished at the freedom of the slags, made perhaps nearly 2,000 years ago, from prills. At this moment, with all my accumulated experience of copper smelting, I don't

These statistics will enable us to form some conception of the value to Ontario of the great copper ranges lying in the Huronian region beyond Georgian bay, as yet but very imperfectly explored, and of the possibilities which await their development.

Fifteen years ago the world's production of nickel was about 600 tons, and in consequence of its comparative rarity and of new uses to which it was found to be adapted the price had in a few years risen in England from 4s. to 11s. per lb.* In 1876 the average price in the United States was $2.60 per pound and the total product 201,367 lb. ; in 1882 the product was 281,616 lb. and the price $1.10 per pound ; but in 1887 the product fell to 205,566 lb. and the price to 65 cents. This was a result of the discovery and working of high-grade nickel ores in the island of New Caledonia, a penal colony of France, about the year 1876, and which in the years 1882-4 produced from 800 to 1,000 tons of metallic nickel, while no new uses were found for it in the arts. Consequently, although the mines of New Caledonia have been worked under unfavorable conditions, the supply exceeded the demand, and prices steadily dropped.† Hitherto nickel has been used for making the alloy known as nickel-silver, which possesses great strength and whiteness, and is produced for the supply of manufacturers of spoons, forks, plated-ware and other articles. It is also largely used in the United States, Germany, Belgium and other countries in the minting of small coins, for which it is well adapted. But recent experiments carried on in Great Britain

The world's production of nickel.

The New Caledonia mines, and their effect on prices.

Alloys of nickel.

know how they made those heavy irony slags so clean. I had but little time to examine the ground, and I failed to find the remains of their furnaces. I failed also to find metallic bottoms, the famous 'Eisensamen' or 'iron pigs,' which almost invariably accumulate in the bottom of blast-furnaces working on ores of this nature, and which do now occur largely in the most scientifically conducted works of Germany and Sweden. Surely these 'old men' knew their business !"—Vivian's Lecture on Copper Smelting, p. 7.

*Phillips' Elements of Metallurgy, p. 362.

†The following account of the New Caledonia nickel mines is given in the report on the Mineral Resources of the United States for 1885 : "The veins, so far as strike and dip are concerned, are fairly regular, striking north-northeast and south-southwest and dipping almost vertically. But the contents vary widely and suddenly in grade. The veins are not very persistent, and it is asserted, after experience which must be considered final, that they do not descend deeper than 300 to 500 feet, even that depth being very rare. The ore is mined by the usual methods and is sorted by hand at the mine and sacked. M. de Peloux describes in detail how frequently the ore is handled, evidently disapproving of it ; he enumerates that the ore of the Thio district, which is best equipped with means of transportation, is handled twelve times. This is partly due to the fact that the sacks are taken to the river bank, the bar at the mouth of which they can only cross at floodtide, and that the beach is so shallow that the ore must again be lightered to the sea-going vessels in the offing, which carry it to the smelting works at Noumea. Thus the irregularity of the ore distribution and the high cost of transportation greatly increase the expense of mining. To this must be added the scarcity of suitable labor in New Caledonia. Among the force available are, first, those transported criminals who are liberated with residences restricted to the colony. They are lazy and difficult to handle. They receive from 6 to 9 francs for eight hours' work. Then there are the natives of the New Hebrides islands, engaged under supervision of the government for a period of three to five years. Although apparently cheap labor, they cost 3 francs a day, are unfit to work in the mines, and are unable to adapt themselves to the climate, from 25 to 30 per cent. always being in the hospital, where the majority die. Their immigration has been finally prohibited by the French government. The Australians are fair miners and good workmen, but they demand at least 12.50 francs a day. Latterly Chinese laborers have been brought in and give better promise, although they require constant watching. Added to the high cost of labor as compared with European standards, there is often trouble through want of water. The ore is taken in lots of 200 to 250 tons to Noumea, where it is worked in two blast furnaces, one of which is used for nickel ores alone and the other for mixed ores of nickel and cobalt. The charcoal and coke come from Australia, and, in spite of the proximity of the two colonies, are very dear. Charcoal costing 12.50 francs at Sydney is worth 40 francs at Noumea, while coke sells at 70 to 80 francs. The object in smelting the ore is to produce a matte carrying from 60 to 70 per cent of metal. It is granulated and shipped to England."—p. 300.

with alloys of nickel and steel seem to justify the hope that a new and valuable use has been found for the metal; and if the claims now made are well founded it is not unlikely that the resources of all known mines may soon be taxed to supply the demand for it.

PROCESSES OF SMELTING ORES.

The Welsh and German systems.

There are various processes for the smelting and refining of copper ores, all of which are well described in Phillips' Elements of Metallurgy, Dr. Percy's Metallurgy and other works, but in the short account here given the writer follows very closely the two greatest living authorities as scientific and practical metallurgists,—Sir Henry Hussey Vivian who favors the Welsh, and Dr. Edward D. Peters who favors the German system.* "When I use the term South Welsh system of copper smelting," Vivian says, "I carefully avoid the term 'principle' of copper smelting, because the same principle must be the base of all copper smelting. The ends are the same, but the means of attaining them are different. The difference lies in our use of reverberatory furnaces both for calcining and melting, while the other systems of the world depend (or perhaps more correctly depended) on roasting in heaps and melting in blast furnaces." Before the Welsh system was introduced three centuries ago the practice had been to roast and melt the ore and regulus repeatedly; as many as sixteen and twenty-two times are mentioned, one-half roastings and one-half meltings, and the time occupied was as many weeks as fires. But with the new system, the inventor of which was one Jochim Gans, the work could be completed in five days.† This practice was adopted with the commencement of copper smelting in South Wales in 1584, and in the following year they were able to smelt 24 cwt. of ore every day with one furnace and to treat any kind of ore, which in 1586 was further increased to three tons per day with a mixture of charcoal and mineral coal, which proves the use of a reverberatory furnace.‡

Origin of the Welsh practice.

* See Copper Smelting, its History and Processes, by Henry Hussey Vivian, M.P., a lecture delivered at Swansea, in the theatre of the Royal Institution of South Wales, December 20th, 1880; and Modern American Methods of Copper Smelting, by Edward D. Peters, junr., M.E.,M.D., 1887.

† The ore was prepared for the furnace by crushing and roasting it, after the vitriol and burnt cinder were carried off by water, which, Vivian says, distinctly proves reverberatory calcining. Nedham (quoted by Vivian) says: "By Mr. Jochims order of working we can—by once rosteing and once smelting the ure (w'ch shall be done in the space of three days) the same copper ure shall yield us black copper and copper stone which nether Mr. Daniell nor his Sonne could or yet can do under xvi times passing through the fire and xvi times doeing thereof, and further in once rosteing and once smeltinge the same black copper and copper stone again, which shall be done in two days after Mr. Jochims order of workeinge, I will bringe the black copper and copper stone into perfect rough copper, which Mr. Stemberger cannot make under xxii tymes passing through the fire and xxii weekes in doinge thereof and sometymes more."

‡ "On the 7th of March, 1586, Ulrick Frosse wrote to Mr. Carnsewe (superintending a mine in Cornwall): 'Wee looke dayley for the copper refiner from Keswicke, and have in readines as much copper roste and blake copper as will make a 20 tonne of good copper.' He reported in the same letter that he 'could melt in 7 hours 24 c. of owre, with 8 or 9 seks of chare coles and 3 horslod of sea coles; melting many sorts of owres to gether is the most proffet and will smelt a greattayll souner.' Now this passage shows that they had so increased their melting as to do upward of three tons per 24 hours, and that they could take any kind of ore, but, above all, it proves that they were using reverberatory furnaces, because 'sea coles' are suitable for such furnaces and not for blast furnaces. The charcoal was probably mixed with the coal to prevent its binding too strongly, just as we now use 'free' coal. The charge of 24 cwt. was curiously enough the same which was used by works up to a recent date. My object in giving these extracts is to show, not alone how copper smelting commenced in South Wales, which is of great local interest, but also how the South Welsh process of copper smelting, which may be said to be at this moment the ruling process of the world, began.'—Vivian on Copper Smelting, p. 13.

There is a great variety of ores and combinations of copper, the purest being the native copper found in the lake Superior mines at Houghton; but the copper of commerce generally occurs in combination with sulphur, and, following Vivian, attention may be exclusively directed here to the smelting of sulphide of copper in combination with sulphide of iron, earthy matters and "every known and unknown metal and mineral in creation."

Varieties of ores.

By smelting is meant fusion of the ore and whatever fluxes may be necessary, when the copper owing to higher specific gravity separates from the slag and is recovered by appropriate means. The first object in the process must be to lose as little of the copper as possible in the slag and to make the fusion easy. In the case of oxidised ores it is obtained at once in a metallic condition, somewhat adulterated with sulphur, iron and other foreign substances, and requires only a single operation or at most two to bring it into merchantable form. But when it occurs with sulphur or arsenic, with an excess of foreign sulphides, the result of fusion is merely concentrated ore, freed from the earthy gangue. It is the first business of the copper smelter to consider the varying nature of his ores. In those containing large quantities of sulphide of iron he takes care to roast or calcine highly in order to obtain oxide of iron to flux the ores and produce a regulus or matte sufficiently rich in copper—his standard being from 30 to 35 per cent. Whether the process is carried on in a reverberatory furnace, a muffle, or in heaps, the object to be obtained is the same in all cases. Of the merits of the different systems Vivian says: "The most ancient, namely, roasting or burning in heaps, is the least costly, provided the copper ore is sufficiently rich in sulphur or bituminous matter, as in the case of the Mansfield Kupferschiefer; but it is not applicable to ores poor in sulphur and in any case it is very tedious, occupying weeks or even months, and therefore necessitating enormous stocks of ore in comparison with the quantity treated. The South Welsh calciner on the other hand is rapid in its action, never exceeding 36 hours and for ordinary ores 12 hours, while the quantity treated is considerable and the cost of fuel and wages consequently small. Our large calciners at Hafod treat 14 tons each charge, the time of course depending on the nature of the ore we are operating on." These calciners are reverberatory furnaces 28 feet long by 13 feet wide, inside, with a small fire-grate at one end, and the ore is spread evenly over the bed of the furnace. They are simple and under complete control, Vivian says; any ore can be treated in them, whether containing much or little sulphur, and the process can be arrested at or pushed to any point. Where it is intended to utilise the sulphur for the production of sulphuric acid three kinds of calciners are used, viz., kilns in which the material is burnt in pieces the size of road metal; the Gerstenhoffer calciner, in which it is burnt as powder, and the muffle calciner, which is worked by transmitted heat.

Treatment of sulphide ores.

Roasting or calcining.

Reverberatory calciners.

Manufacture of sulphuric acid.

In weighing the advantages and disadvantages of the reverberatory and blast furnace systems of smelting the calcined ore, Sir H. Vivian says the blast furnace is slightly more economical in the cost of fuel, and in all cases it produces a cleaner slag; but he contends that its working is much more complicated, and through its tendency to reduce the oxide of iron in the ore

The reverberatory and blast furnace systems compared.

into metallic form it is liable to produce a mass of infusible matter at the bottom of the furnace, which causes its partial or entire destruction. A second drawback to the blast furnace is that it can only treat a comparatively rough mixture, as much fine ore would choke it. A third disadvantage of the blast furnace is that it fails to produce a regulus as fine and rich in copper as the reverberatory furnace, which means that more expense has to be incurred in the subsequent processes. "The reverberatory furnace is a simple and easily worked furnace, forming no metallic bottoms until the copper stage is reached, and capable of dealing with all ores, as Ulrick Frosse found out three hundred years ago." But Sir H. Vivian's knowledge of blast furnaces was limited to the rectangular and round brick furnaces, such as have commonly been used in Germany, which required constant repairs and attention to prevent burning up and freezing out. For a fair comparison of the two systems the improved water-jacketed blast furnace now used in the United States and Canada should be taken instead of the now antiquated German one.*

The water-jacketed blast furnace.

At Swansea, as Dr. Peters observes, a great variety of ores is used, brought from all quarters of the world, differing in richness, purity and other qualities—sulphide ores, oxides and carbonates. Coal is cheap also, and refractory material is obtainable at prices far below American rates. At the Swansea works also there is a body of skilful workmen who have grown up at the furnaces, and who at very low rates of wages are capable of executing all difficult operations demanded by the system of treatment. There is, too, a market where every variety of metal brings the highest justifiable price. Under American conditions, on the other hand, the ore usually comes from one or two sources, constant in its composition and usually in large quantities; while wages are high and fuel and refractory material is expensive. These conditions however have shown the necessity of economy of labor and material; they have demanded improvement in processes, and have resulted in perfecting the water-jacketed cupola. The adaptation of the principle of water-cooling to copper blast furnaces, Dr. Peters says, may be hailed as the greatest advance in the treatment of that metal made since the introduction of the English method of refining on the hearth of a reverberatory furnace. The burning out and freezing up of the the furnace from the half-fused masses of molten fire-brick have with its employment become a thing of the past. Where no accident occurs nothing compels stoppage of the furnace excepting the need of general repairs to the machinery, cleansing the interior of the jacket from sediment and the possible choking up of the furnace shaft with

Advantages of smelting conditions at Swansea.

A necessity for improvement.

The water-cooled furnace and how constructed.

* "Since blast furnace smelting has obtained a footing in the United States," Dr. Peters says, "it has become so changed from its original as to be scarcely recognisable, and as here used by the more advanced metallurgists can challenge competition with the reverberatory under most circumstances, and where the conditions are at all favorable can show results far surpassing the best Swansea work in yield, economy and capacity. That this may seem novel or even doubtful to English smelters is quite natural, when it is recollected that the full extent of these remarkable advances is known to comparatively few metallurgists, and that very little relating to the same has been published. It is with the modern American form of the German copper process that all comparisons must be instituted; and this comprises not only a great improvement in the processes of calcination and the construction and management of blast furnaces used, but in many cases the employment of reverberatories for certain portions of the matte concentration, while the process of refining is in all cases carried on according to the Swansea method."—Modern American Methods of Copper Smelting, p. 171.

accretions of sulphides of zinc or lead, which occur in minute proportions in all copper ores. The material of the jacket may consist of cast iron, wrought iron or mild steel ; but the brand known as fire-box iron is less liable to scale and blister by heat, and is capable of being bent without weakening.

Besides its excessive weight cast iron is somewhat liable to crack when exposed to extreme fluctuations of temperature. With wrought iron the thickness need not exceed ordinary boiler plate, and the tendency of the inner plate to weaken owing to difference of expansion has been overcome by using an elongated oval-shape instead of the rectangular—a modification introduced by Herreshoff of New York. The ordinary blast in copper smelting does not exceed three-quarters of a pound per square inch, and this cannot penetrate to the centre of a charge in a furnace of greater diameter than 50 inches where half the charge is in lump form, and so the largest Herreshoff furnace is only 48 inches in diameter. The width of the water space has been diminished little by little until even two inches has become a not uncommon standard, and the constant flow of water into and out of it keeps the inner plate of the cupola from damage by the excessive heat of the molten mass within. The cold feed of water is generally introduced near the middle or lower portion of the jacket, and doubtless settles to the lower part at once to rise gradually as it becomes heated and escape through a pipe of somewhat greater diameter than the inlet pipe from the upper portion of the jacket.

The Herreshoff furnace.

If tapped in such a way that the escape pipe is on a level with the extreme upper surface it prevents the accumulation of any steam which might form, while the accumulation of sediment introduced in the water can be easily removed through the hand-holes provided for that purpose. The furnace jacket is also supplied with a drain-cock to empty it when not in blast, in cold weather or when repairs are required. The bottom of the furnace is a foot or less below the tuyeres, from which the entire molten mass escapes through a narrow groove into an outside crucible or well in which the matte separates from the slag and is tapped into moulds or pots, while the slag flows from a spout into pots arranged on wheels for convenient dumping. It is this transfer of the crucible from the inside to the outside of the furnace that has divested cupola work of most of its terrors, for by this means the troublesome chilling over of the metal in the crucible and the frequent freezing over of the tap-hole are avoided, which otherwise would make the emptying of the furnace impossible without great difficulty.* With the old form of crucible in the interior of the furnace the cutting out of a chilled mass, which sometimes formed, was a costly and tedious operation, comprising the blowing out and cooling down of the furnace, whereas if the exterior well becomes unworkable from any cause it can be disengaged from the furnace and another put into its place in twenty minutes—the stoppage of the blast for so short a time causing no trouble in the furnace. It is by such improvements as are here described that the blast furnace has come into general

The well or fore-hearth.

* "The first well used in connection with a copper furnace in this country was built by James Douglas, jr., at his Phœnixville works, in 1879."—Dr. Peters' Modern American Methods, p. 179.

favor for the smelting of copper ore in America, and one may doubt if under the most favorable conditions the reverberatory furnace surpasses it in the production of matte.

THE BRUCE MINES SMELTING WORKS.

Smelting at the Bruce and Wellington mines.

The efforts at copper smelting at Bruce Mines are for the most part a tradition. The books of the company were destroyed in a labor riot, its annual reports are not accessible, the Geological Survey volumes are silent on the enterprise; we are dependent for information mainly upon personal recollections, and these cannot be very accurate after an interval of a quarter of a century, especially as regards details and statistics. The statements in the evidence of Messrs. Borron, Prout and Plummer however are important and valuable, and the general causes of the failure of smelting operations at the Bruce and Wellington mines are no doubt correctly stated. The cost of production could not fail to be heavy under the circumstances of time and place. Fuel was dear owing to the cost of freight, for the lake Superior traffic had scarcely begun to develop even when the works closed; the rate of wages for labor ruled high, and labor itself was neither very efficient nor reliable; and the processes adopted, as well as the direction of the works, it may readily be believed, were not adapted for the insuring of economic production. The testimony of Mr. Borron on these aspects of copper smelting at Bruce Mines may furnish a useful lesson to any who may contemplate the establishing of similar works there or at any other point in the northern districts. The Welsh system failed, and so also did the salt process tried afterwards at the Wellington mines; so also, it is almost certain, would the blast furnace system had it been tried with the old fashioned furnace of that time.

THE SUDBURY SMELTING WORKS.

The blast furnace system Sudbury.

The smelting works of the Canadian Copper company at Sudbury have been set up under the direction of Dr. Peters, the well known metallurgist and author, to whom frequent reference has already been made. The blast furnace system has been adopted at those works, and the ore is prepared for smelting by being roasted in large heaps in the open air. The Copper-cliff, the Evans and the Stobie mines furnish the supplies of ores, and although they are all of the same class their composition varies considerably. Nine assays of raw ore taken without selection from these mines, made by Mr. Sperry for copper and nickel in November, 1888, to show how the ore ran in the mass, gave the following results:

——	1.	2.	3.	4.	5.	6.	7.	8.	9.
Copper....	4.62	5.52	4.95	9.98	4.03	5.00	7.91	9.94	5.97
Nickel	1.16	1.13	3.26	1.12	4.21	3.30	1.50	2.75	3.00

This gives an average of 6.44 per cent. of copper and 2.38 per cent. of nickel. The other contents of the ore are silica, alumina, lime, magnesia, iron and sulphur, and as mixed for the furnace they are found to be in suitable proportions for flux. The ore is run through crushers at the Copper-cliff mine and is graded according to size, after which it is loaded on cars and taken over an

elevated track to the roasting yard, located about three hundred yards from the smelting furnace. The beds of the yard have been made with layers of clay and gravel, for the want of better material, and shallow drains have been cut for the purpose of drawing off water in the event of a heavy rainfall during the roasting operation. About thirty beds have been prepared in this way, and each heap when finished contains from 400 to 600 tons of ore. In building a heap a layer of fine ore is spread upon the bed to the depth of six inches, and over this a layer of wood to the depth of eighteen inches. The fuel used is dry pine—the remains of an extensive forest fire which swept over this country some fiften years ago. It is laid with frequent openings for draughts along the sides and ends, while sticks are set on end at intervals throughout the heap to serve as chimneys. The wood is covered with coarse ore to the depth of two or three feet, and this in turn by fines to prevent a too rapid combustion, the whole when completed making a pile about six feet high. The fire is set to kindling material in the draught openings, and as it spreads and the heat increases the sulphur of the ore adds to the fuel, sending up a heavy, yellowish cloud of acrid smoke. The heap burns from thirty days to seven weeks, according to its size and the quality of the ore,—that which contains the largest proportion of sulphur and iron requiring the longest time. For rapid and effective roasting the heaps should be covered to keep off rain or snow; but as covering of any kind would interfere with the free escape of the smoke this is not desirable for the health or comfort of the attendants, as at the best a roasting yard is as unsavory as a gehenna. It is found at Sudbury that roasting in this way is done satisfactorily and cheaply, largely reducing the percentage of sulphur and uniting oxygen with the iron, so that the ore as taken from the heaps is self-fluxing. An analysis of roasted ore made in December, 1888, to enable the furnace manager to make up a charge for smelting, gave 5.40 per cent. of copper, 2.43 per cent. of nickel, 7.92 per cent. of sulphur, 25 per cent. of iron, lime, magnesia, etc., and the residue chiefly of hornblende. An experienced workman knows the difference in the quality of roasted ores at sight, and is able to mix them roughly as they are loaded into the cars at the heaps to be taken to the smelter and dumped into separate bins. Here they are again mixed by the furnace men in making up the charge so as to produce the quality of matte required.

The roasting yard.

How a heap is built.

Composition of the roasted ore.

The furnace set up at the works was manufactured by the Jenckes Machine company of Sherbrooke, Quebec, after the Herreshoff patent. It is nearly elliptical in form, having a longer diameter of 6 feet 6 inches and a shorter of 3 feet 3 inches at the tuyeres, increasing in size upwards, and is 9 feet in height to the charging door. It is made of rolled steel, with a water space of two inches between the outer and inner plates, and has for bottom a cast-iron plate protected with fire-brick—the whole resting on four strong iron supports. A light dome of plate steel, brick-lined in the crown and sides, covers the furnace; and in one side of this dome, on a level with the ore bins, is the feed door. A cross-flue or dust chamber connects the dome with the chimney. The well, fore-hearth or settling pot is made of double plates of cast iron, having a water space of six inches, and rests upon four wheels for conveni-

Description of the furnace.

ence of moving it whenever repairs are necessary, a second well standing ready to be put in its place. A square opening on one side is fitted by fire-clay to a corresponding opening in the furnace, through which the molten mass flows when the furnace is in blast. The blast is furnished by one of Baker's rotary blowers, and enters the furnace through eleven tuyeres under a pressure of 8 to 10 ounces per square inch. A charge consists of 1,800 to 2,000 lb. of ore and coke, mixed in the proportion by weight of eight of the former to one of the latter, and at the usual speed of driving the furnace it smelts 120 tons of ore per day, sometimes reaching 150 tons. As the molten mass gathers at the base of the furnace it flows through the discharge hole into the well, where the heavier or metallic portion sinks and the lighter slag rises to the surface, to flow out in a constant stream of liquid fire at the slag-spout and be rolled in the pots in which it is caught to the waste heap. The matte is drawn at frequent intervals through a tap-hole at a lower level, which is opened with a pointed rod of iron and afterwards closed with a ball of fire-clay.* It is bright and sparkling in appearance and flows very freely, but occasionally shoots out like the discharge of a Gatling gun, to the terror of the fresh onlooker, and mayhap to the serious hurt of one or more of the furnace men. The matte is allowed to cool in pots, after which it is ready for shipment to the refining works. Its composition is shown by the following analyses, the first of which was made by Mr. Sperry on the 22nd of February and the second on the 2nd of March, 1889:

Material.	1.	2.	Average.
	per cent.	per cent.	percent.
Copper	27.06	26.76	26.910
Nickel	14.44	13.84	14.140
Iron	31.00	31.47	31.235
Sulphur	26.90	27.00	26.950
Cobalt	.27	.20	.235
Slag	.92	.95	.935
Totals	100.59	100.22	100.405

Some shipments show a higher analysis and some a lower, but Mr. Sperry states that the two given above are fairly representative of the average run. The furnace was blown in on the 24th of December, 1888, but owing to a fault in the construction regular work was not commenced until February, 1889, and in the four months ending with May the total product of matte was about 1,200 tons. This would give at the refinery, on the basis of the above analysis, 320 tons of copper and 170 tons of nickel. A second furnace

Capacity of the furnace.

Composition of the matter.

*The matte and slag taps, it should be stated, are water-jacketed also, each being fed by its own pipe, and as the water flowing through the jackets never rises to the boiling point little injury is done by the intense heat to the material of the furnace, well or taps. Without this protection a steel or iron furnace would no doubt require repairs as frequently as the old fashioned German furnace itself.

of the same capacity as the first was set up during the summer of 1889, and was blown in on the 4th of September.*

No works for the refining of matte have yet been erected in Ontario, but, with the promise of an abundance of material to treat, it is not improbable that this need of a completed industry will be supplied. The process is difficult, tedious and costly, and this is an additional reason for its being carried on at home instead of shipping the matte to New Jersey, Maryland or Wales. Refining works.

ALLOYS OF NICKEL AND STEEL.

The production of copper and nickel in Ontario would seem to be limited only by the skill and enterprise of those who may engage in the industry. The number and extent of ranges already located give promise of a supply equal to any demand which may arise for many years to come, and as yet only an insignificant area of the formation bearing the copper and nickel ores has been explored. Any new purpose therefore to which one or other of these metals may be applied possesses great interest not only to the companies engaged in opening and working the mines but to the whole province also. As regards copper, it has been employed in the arts for so many centuries that we should be surprised were even modern scientific metallurgy to find out a new application of it. When we read that nearly three thousand years ago the treatment of alloys of copper and tin had reached such a stage of perfection that founders cunning to work all works in brass were able to cast pillars $31\frac{1}{2}$ feet in length and $21\frac{1}{2}$ feet in circumference, adorned with lily work, and a bath of 20,000 gallons capacity $8\frac{3}{4}$ feet in height and $52\frac{1}{2}$ feet in circumference set upon twelve figures of oxen cast when it was cast,† we may almost despair of new and valuable use being found for copper. The outlook for skill and enterprise. Antiquity of copper and tin alloys.

But nickel is a modern metal, having only been discovered in 1751, and until recently it was hardly known in the pure state. Some specimens of wrought and forged nickel were shown for the first time at the Philadelphia exhibition of 1876 by Mr. Wharton of the Camden works, but they attracted no attention. In 1878 those specimens were sent to the Paris exhibition, and there as in Philadelphia they did not at first excite any surprise or receive Nickel a modern metal.

* Since the above was put in type Mr. H. P. McIntosh of Cleveland, the secretary of the company, has furnished the following particulars of smelting operations at Sudbury to 31st December, 1889: "Our No. 1 furnace was blown in for the first time on December 24th, 1888, and ran from that time to December 31st, 1889, 259 days of 24 hours, using 31,268 tons of ore and producing therefrom 3,849 tons of matte averaging probably about 18 per cent. copper and 13 per cent. nickel. In this operation there were consumed 3,950 tons of Connellsville coke, costing about $6.50 per ton at Sudbury. Smelter No. 2 started September 4th, 1889, and ran 73 days from that period to December 31st, using 9,740 tons of ore and producing 1,210 tons of matte averaging probably about the same per cent. copper and nickel as No. 1. This furnace consumed 1,169 tons of coke. Shipments have been made to Philadelphia, New York, Swansea, Liverpool and Hamburg. Our coke is shipped by boat from Cleveland to Algoma Mills and thence over the Canadian Pacific railway to Sudbury." The shaft at Copper-cliff mine is sunk at an angle of 45°. On the 31st of December, 1889, it had reached a depth of 502 feet, and the width of the ore deposit at that depth was 65 feet.

† See I Kings chap. vi, and II Chronicles chap. iii and iv. Brass is an alloy of copper and zinc while bronze is an alloy of copper and tin, and as zinc does not appear to have been known at the time of Solomon it is assumed that when brass is spoken of in the Bible an alloy of copper and tin is meant. Referring to the sea or washing basin cast by Hiram for the temple, Vivian says: "To make such a casting a large quantity of metal would have to be melted at once, not probably in crucibles but in a cupola or reverberatory furnace, and great skill would be required in manipulating so heavy a casting. It is also clear that the art of moulding was well understood." Tubal-Cain, who was seventh in descent from Adam, was an instructor of every artificer and the forger of every cutting instrument of brass or copper and iron.—Genesis iv—22, R.V.

any special attention. "Very few persons realised what the objects really were," W. P. Blake wrote in the volume of Mineral Resources of the United States for 1883, "and that they were very different from *alloys* of nickel. In fact very few chemists had ever seen nickel. Pure nickel was a rarity, a curiosity, just as samples of indium and thallium are to-day. It was not strange therefore that the expert chemists and metallurgists of Europe on the international jury showed some incredulity and surprise when whole ingots and forged bars of metal and numerous finished articles of pure wrought nickel without alloy were offered for their inspection." This notable advance, Mr. Blake says, prepared the way for greater advances, one which he mentions being the addition of a small quantity of magnesium to the charge of molten metal when it is ready to be poured. With the addition of an ounce of magnesium to 60 ℔. of nickel, the metal becomes remarkably tough and malleable and may be drawn into wire or rolled into sheets as thin as paper. Dr. Fleitman of Iserlohn, Prussia, has also succeeded in welding sheet nickel upon iron and steel plates so as to coat them equally on each face, the two metals being so nearly the same in their physical properties that they work well together and adhere tenaciously.*

Exhibits of specimens of pure nickel at Philadelphia and Paris.

Progress in treatment of the metal, and new uses found for it.

But doubtless the most important discovery of the use of nickel is its alloy with steel, made almost simultaneously by Mr. J. F. Hall of Sheffield, England, and Mons. Marbeau of France, an account of which is given in the Journal of the Iron and Steel Institute, No. 1, 1889.

Discoveries of Hall and Marbeau.

A number of experiments of alloys of nickel and iron are mentioned by Dr. Percy,† none of which appear to have been very satisfactory. Horse-shoe nails melted by Faraday and Stodart with 3 per cent. of nickel gave an alloy that was quite as malleable and pleasant to work under the hammer as pure iron. When melted with 10 per cent. of nickel the alloy was less malleable and more disposed to crack under the hammer: it rusted less quickly than pure iron, whereas the same quantity alloyed with steel accelerated rusting very materially. An alloy of 8.3 per cent. of nickel with iron, prepared by Berthier by the reduction of the mixed oxides of both metals in a brasqued crucible, was semi-ductile, very tenacious and fine-grained, but somewhat scaly in fracture. A series of four experiments conducted in Dr. Percy's own

Early experiments with alloys of nickel, iron and steel.

*"The applications in the arts of such nickeled iron sheets will readily suggest themselves. Up to this time the most direct uses seem to be in making hollow ware, particularly culinary vessels. The manufacture of such ware has already begun at Schwarte by Dr. Fleitman, and a great variety of vessels, such as saucepans and kettles, have been turned out, some of them of pure sheet nickel. They are all very beautiful in appearance, resembling highly finished platinum vessels more than ordinary ware. When planished and buffed up the surface becomes like a mirror, and will answer the purpose of one. The vessels already sent to this country as samples are made of nickeled iron, and show the facility with which the compound sheet metal may be stamped, spun up and polished. This ware is far superior to tinned iron or tinned copper for cooking in. Experiments have shown that it is not poisonous. The nickel is not only less liable to corrosion, but is harder, will last longer and cannot be melted off by overheating. The ware is lighter and stronger than tin or copper ware, is susceptible of a high polish and is not easily tarnished. It is well adapted to the manufacture of dishes, salvers and covers for the table. The coating of nickel applied by welding is stronger and tougher than that deposited by electrolysis, and appears to be less liable to scale off. The electrically deposited metal is in some cases very brittle, and no doubt contains sufficient hydrogen to essentially modify the physical characters of the coating. This new application of nickel constitutes practically a new industry of great importance. It increases the consumption of nickel and will stimulate its production, and by giving a steady demand will no doubt lead to a more uniform and constant supply."—E. P. Blake in the Mineral Resources of the United States, 1883, p. 420.

† Metallurgy of Iron and Steel, p. 171.

laboratory with 1, 5, 20 and 50 per cent. of nickel, gave varying results. The nickel was practically pure, the iron was in a state of fine wire, fusion was effected under plate glass in clay crucibles and the metals appeared to alloy perfectly together. (1) With 495 grains iron and 5 grains nickel, the loss in alloying was 10 grains; and when cut half through with a cold chisel the remainder broke, the fracture being in all respects similar to that of pure iron. (2) With 285 grains of iron and 15 grains of nickel the loss was 10 grains; the alloy seemed to be perfectly made, but it was more brittle than No. 1 and the fracture was bright and finely granular. (3) With 240 grains of iron and 60 of nickel the loss was 20 grains; the surface was smooth and free from scale, differing in that respect from 1 and 2, but the alloy was brittle and on cutting across with a chisel it broke with an extremely irregular fracture. (4) With 200 grains each of iron and nickel the loss was 20 grains; the alloy was smooth and free from scale, but tarnished, and while it flattened sensibly under the hammer it was brittle; the fracture was even, uniform and finely granular. Alloys of iron and steel with nickel made by Wolf of Schweinfurth and examined by Liebig, Percy says, had the aspect and properties of genuine Damascus steel, and the nickel iron acquired likewise by the usual process a magnificent damask.*

Those experiments were conducted by chemists and metallurgists of high reputation,† and when the results are compared with others obtained within the last two years by practical men of unquestioned skill it does not seem possible to account for the causes of failure on one side and of success on the other without further details of the processes than the records afford.

Riley's experiments at the Glasgow steel works.

At the meeting of the Iron and Steel Institute of Great Britain in May, 1889, a paper was read on alloys of nickel and steel by Mr. James Riley, manager of the Glasgow steel works, which has awakened great interest throughout Europe and America. Some months before Mr. Riley had been asked to examine specimens of manufactures of various alloys of nickel and iron made according to a process patented by Mons. Marbeau of France. The British patents obtained for these manufactures, Mr. Riley states, had previously been submitted to him, but their consideration had not caused him to feel much interest in them. But when he examined the products themselves his interest was much excited and he entered on a course of investigations regarding the alloys which was still in progress when his paper was given to the Institute. Some time after the conclusion of preliminary tests made upon ingots sent for treatment and examination a visit to the works in France was arranged, with the object of seeing the process of manufacture and the certainty with which products could be obtained from the crucible. This was demonstrated, Mr. Riley states, to his entire satisfaction, the composition of the casts being varied at will and the qualities and properties of the metal indicated beforehand. Afterwards M. Marbeau visited the Glasgow

* W. P. Blake in U. S. Mineral Resources, 1883, p. 416, mentions that experiments by Bouissingault with 5, 10 and 15 per cent. of nickel added to iron showed that the alloy rusted as freely under water as steel without nickel.

† They are recorded in scientific journals and metallurgical works dating from 1820 to 1864, but great advance has been made in knowledge of the properties of metals in the past quarter of a century.

steel works and charges were made which showed that the composition of the metal can be as effectually controlled in the open hearth furnace as in the crucible.*

In endeavoring to obtain a correct idea of the utility of the alloys of nickel, iron and steel, Mr. Riley made a careful examination of their behavior under tensile and other mechanical tests. But as chemically pure iron is practically unknown, and as the presence of very minute quantities of carbon, silicon, sulphur, phosphorus etc., in varying proportions produce marked changes in the qualities of iron,† it is necessary that the percentages of each should remain constant in order to estimate correctly the influence of the addition of nickel. Twelve tests with varying contents of nickel, the results of which are reported by Mr. Riley, prove how necessary it is to know all the conditions before any certain conclusion is reached, and possibly it was in this particular that the earlier experiments failed. The contents of nickel in the iron, as shown by the records of Mr. Riley's tests, varied from 1 to 49.4 per cent., the carbon from .22 to .90 per cent., and the manganese from .23 to .85 per cent. With 2 per cent. nickel, .90 per cent. carbon and .50 per cent. manganese, and also with 4 per cent. nickel, .85 per cent. carbon and .50 per cent. manganese, the alloys were too hard to machine with musket steel, but they made a fine tool when tempered at dull red in boiling water; while with 10 per cent. nickel and .50 per cent. each of carbon and manganese it was too hard to machine, but made a good cutting tool when tempered in a cold air blast. This extreme hardness is stated to be due to the large quantity of carbon present, but also to the presence of nickel in addition. "This quality of hardness obtains as the nickel is increased," Mr. Riley observes, "until about 20 per cent. is reached, when a change takes place and successive additions of nickel tend to make the steel softer and more ductile, and even to neutralise the influence of car-

Mechanical tests of the alloys.

Peculiar effects of nickel on steel.

* "The alloy can be made in any good open hearth furnace working at a fairly good heat. The charge can be made in as short a time as an ordinary 'scrap' charge of steel—say about seven hours. Its working demands no extraordinary care, in fact not so much as is required in working many other kinds of charges, the composition of the resulting steel being easily and definitely controlled. No special arrangements are required for casting, the ordinary ladles and moulds being sufficient. If the charge is properly worked nearly all the nickel will be found in the steel—almost none is lost in the slag, being in this respect widely different from charges of chrome steel.

"The steel is steady in the mould, it is more fluid and thinner than ordinary steel, it sets more rapidly, and it appears to be thoroughly homogeneous. The ingots are clean and smooth in appearance on the outside, but those richest in nickel are a little more 'piped' than are ingots of ordinary mild steel. There is less liquation of the metalloids in these ingots, so that liability to serious troubles from this cause is much reduced. Any scrap produced in the subsequent operations of hammering, rolling, shearing, etc., can be remelted in making another charge without loss of nickel. The importance of this fact will be at once appreciated, especially by users of articles made of this metal, seeing that scraps and old articles will have a value for remelting in proportion to their contents of nickel.

"No extraordinary care is required when reheating the ignots for hammering or rolling. They will stand quite as much heat as ingots having equal contents of carbon but no nickel, except perhaps in the case of steel containing over 25 per cent. of nickel, when the heat should be kept a little lower and more care taken in forging.

"If the steel has been properly made and is of correct composition it will hammer and roll well, whether it contains little or much nickel; but it is possible to make it of such poor quality in other respects that it will crack badly in working, as is the case with ordinary steel."—James Riley in the Journal of the Iron and Steel Institute, No. 1, 1889. p. 46.

†Sir James Kitson states that ingot iron alloyed with so small a proportion of aluminium as 0.1 per cent. melts at a comparatively low temperature, is very liquid in the molten state, and can be cast into solid and homogeneous objects possessing the strength of wrought iron. —Journal of the Iron and Steel Institute, No. 1, 1889, p. 25.

bon, . . but I am glad to be able to state that before the region of extreme difficulty of machining is reached we have qualities of nickel steel available which will be of the utmost value for a very large number of purposes." With 25 per cent. nickel, .27 per cent. carbon, and .85 per cent. manganese the ductility as shown by the extension before fracture was marvellous, showing 40 per cent. in eight inches. In No. 6 test, with 4.7 per cent. nickel, .22 per cent. carbon and .23 per cent. manganese, the addition of the nickel raised the elastic limit from 16 up to 28 tons, and the breaking strain from 30 up to 40.6 tons when annealed, without impairing the elongation or contraction of area to any noticeable extent. Of a series of hardening and tempering tests Mr. Riley says: "We have tested pieces up to 87 tons breaking strain with 52 tons elastic limit; but there is a piece before you, furnished by the patentee, which was tested by us and gave b.s. 95.6 tons, e.l. 54 tons, extension in four inches 9.37 per cent., contraction of area 49.2 per cent. Two similar pieces tested by Mr. Kirkaldy gave b.s. 94.18 and 93.86 tons, e.l. 52.01 and 53.92 tons, extension 7.8 and 8.2 per cent., and contraction of area 52.4 and 50 per cent. respectively."* In torsion or twisting tests the results were equally satisfactory, the one set confirming the other as regards breaking strain and elastic limit, while the number of twists were found to correspond closely to the ductility as measured by extension in the tensile tests.† Torsion tests.

The whole series of nickel steels up to 50 per cent. were found by Mr. Riley to take a good polish and finish, the richer ones having a lustrous appearance. Up to 5 per cent. nickel it was found that the alloys could be machined with moderate care, while the poorer ones stood punching exceedingly well both as rolled and after annealing; the punch-holes can be put as close together as $\frac{1}{8}$-inch without the metals showing any signs of cracking. As to the welding quality however this was found to deteriorate with each addition of nickel above one per cent. "In the very important matter of corrodibility," Mr. Riley stated, "it is with the greatest satisfaction I can state that the steels rich in nickel are practically non-corrodible, and that those poor in nickel are much better than other steels in this respect." Experiments made with 5 per cent. nickel steel as compared with mild steel of .18 per cent. carbon showed corrosion in the ratio of 10 to 12, and as com- Other qualities of nickel steel. Non-corrodible.

* The breaking weight of a bar of iron having a sectional area of one inch when hung at one end is given by Sir Lowthian Bell at 6 to 14 tons for cast iron, 20 to 30 tons for wrought iron and 28 to 60 tons for steel. Trials at the Royal Arsenal, Woolwich, recorded by Jeans, give the tensile strength of Bessemer iron and steel to the square inch as follows: Iron as cast and unhammered (mean of 5 trials) 18.41 tons; hammered or rolled (mean of 5) 32.43 tons Steel in cast and unhammered state (mean of 8) 28.13 tons; hammered or rolled (mean of 7) 68.26 tons. The power and delicacy of testing machines is shown by a trial of the Emery machine at the Watertown arsenal. It is capable of exerting a stress of 800,000 lb. and of testing specimens up to 30 feet in length. Before acceptance, a link of hard iron five inches in diameter was placed in the machine and slowly strained in tension till it broke at 722,000 lb. Without any adjustment a horse hair was then fixed in the machine and broken at an indicated stress of one pound.—See Journal of the Iron and Steel Institute, No. 1, 1889, p. 379.

† "This alloy," Sir James Kitson stated in his address as president of the Institute, "promises to be of great commercial value. I have here test pieces of two bars which were cut out of a 10-ton armor plate made in France. The pieces were forged down into shape. They contain 5 per cent. of nickel and give a tensile strain of 90 tons with an elongation of 8 per cent. It is claimed that with 5 per cent. of nickel there is almost entire freedom from corrosion. Nickel steel has extreme fluidity and is very sound."—Journal, No. 1, 1889, p. 26.

pared with steel of .40 carbon and 1.6 chromium a ratio of 10 to 15. In the case of 25 per cent. nickel these ratios were as 10 to 870 and 10 to 1,160 respectively. These results were obtained by immersion of the samples in Abel's corrosive liquid, and afterwards confirmed by immersion in water acidified by hydrochloric acid.*

Hall's experiments.

In the discussion which followed the reading of Mr. Riley's paper it was stated by Mr. J. F. Hall of Sheffield, also a manager of steel works, that he had been carrying on experiments with alloys of nickel and steel for about two years and had taken out a patent for his invention.† This is for

* In concluding his paper Mr. Riley indicated some of the possible uses to which these alloys may be applied as follows:

"It requires no powerful imagination to conjure up a most bewildering number of applications for which they are available. I find some difficulty in not becoming enthusiastic on the point, for in the wide range of properties or qualities possessed by these alloys it really seems as if any conceivable demand could be met and satisfied.

"Of the richer alloys I do not intend to speak at any length, but would just remark that in the immense field covered by what are termed the 'Metal Trades' innumerable applications will be found for which they are suitable. Some specimens of these applications are before you.

"Of the 25 per cent. nickel steel I would remark that with its peculiar properties of high b.s., great ductility and *comparatively* low e. l. it is extremely well adapted for all operations involving considerable deformation—for instance, for deep stamping and flanging —whilst its non-corrodibility will render it invaluable for a great number of purposes.

"This quality of non-corrodibility, considered together with its strength, both elastic and ultimate when unannealed, will render it specially useful in all cases where the cost of metal is of minor importance when contrasted with the cost of labor to be expended upon it, or its use for special purposes: illustrations of these may be found in all small and special type boilers, in locomotive and other fire-boxes, and in the hulls of torpedo and other similar vessels where lightness and strength with non-corrodibility are of vital importance.

"In the region between 25 per cent. and say 5 per cent. nickel we have an abundance of possibilities as yet comparatively unknown, in which I expect will be found materials for tool-steel equal if not superior to anything at present known.

"But it is when we get to the alloys of 5 per cent. and under that I feel most interested, and I think most of you will sympathise with that feeling.

"I have already incidentally referred to the advantages the marine engineer will obtain by the use of these qualities for the shafts and other forgings used in his structures. I would now point to the suitability of these lower alloys to the other portions of his work. It is well known—it has been frequently stated by my friend Mr. Parker and others—that the recent advances in marine engineering, rendered possible by the use of high-pressed steam, could not have been effected if it had not been that a metal superior to wrought iron was put at the engineer's disposal. Conceive then of the possibilities now presented when a metal like No. 6 in the table No. 1 is at his disposal, having when annealed an ultimate strength of 30 per cent. and elastic limit of 60 or 70 per cent. higher than those of mild steel, with a nearly equal ductility, and the valuable quality added of less liability to corrosion. He may at once greatly reduce his scantlings for pressures and get rid of many difficulties of construction, or he may avail himself of the increased strength to provide for still higher pressures.

"It will also be seen that these metals are equally important to the shipbuilder and to the civil engineer. This is strongly brought out in considering the immense advantage to be derived from their use in large structures. Think for a moment of this in connection with the erection of the Forth bridge or of the Eiffel tower. If the engineers of those stupendous structures had had at their disposal a metal of 40 tons strength and 28 tons elastic limit, instead of 30 tons strength and 17 tons elastic limit in the one case and say 22 tons strength and 14 to 16 tons elastic limit in the other, how many difficulties would have been reduced in magnitude as the weight of materials was reduced; the Forth bridge would have become even more light and airy and the tower more net-like and graceful than they are at present.

"Then, as regards the requirements of the military engineer, I am inclined to state firmly that there has not yet been placed at his disposal materials so well adapted to his purposes—whether of armor or of armament—as those I have now brought under your notice.

"In what may be called their natural condition these alloys have many properties which will commend them for these purposes, and when the best method of treatment by hardening or tempering has been arrived at I believe that their qualities for armor will be unsurpassed."

† Mr. Hall's provisional specification for 'Improvements in Alloys containing Iron and Steel' is dated March 5th, 1888, and the complete specification on the 5th of December in the same year. Following is a copy of the complete specification:

"I, John Francis Hall of Norbury, Sheffield, in the county of York, manager of steel works, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:

"This invention refers to the manufacture of a new alloy of steel or iron and nickel, having for its object to produce a metal or alloy combining great strength with toughness,

the use of nickel in steel in any proportions from $2\frac{1}{2}$ to 50 per cent., and Mr. Hall has carried out a large series of experiments to prove its value. A gun-barrel of nickel steel was tested by Messrs. Holland and Holland of New Bond street, London, an eminent firm of gun-makers, and showed surprising strength. In practice three drachms of powder and one ounce of shot are used for a 12-bore gun, but in tests four or five drachms of powder and an ounce and a half of shot are used. "Nine tests in all were carried out," Mr. Hall said, "the ninth test contained fifteen drachms of powder, three ounces and a half of shot and double wadding. At that charge the gun-barrel burst, but it did not burst in the real sense of the word, for it was merely opened and laid out flat. The maker of that gun, who had probably made more high-class guns than any other person living, informed the speaker that he never in all his experience had seen or could imagine such a piece of material." Mr. Hall also stated that in one of his experiments he had got a tensile strain of 97 tons, with an elongation of a little over 7 per cent.*

Consideration of cost as a bar to use.

The cost of nickel was, in the opinion of several members of the Institute, a serious objection to its extensive use. Sir James Kitson however did not attach any importance to cost, recalling the fact that when steel tires for locomotives were first extensively introduced into Great Britain by Krupp they were sold in the market at £120 per ton, and at that price they made their way against Lowmoor tires of one-third the price. Therefore he thought that a metal which gave a tensile strain of 50 tons, with an elongation of 50 per cent., was sure to make its way if the claims which Mr. Riley had made were justified by experience.†

It does not seem likely however that the cost of nickel will long stand at 50 cents per pound, when it is remembered that within ten years of the

also possessing a very close grain or texture, thus rendering it capable of receiving a brilliant polish.

"I wish it to be understood that I am aware that steel has prior to this my invention been treated with nickel, but only in very small proportions, rarely exceeding one per cent. and never above two per cent. of nickel (as a matter of fact one per cent. may be taken as the full extent of the addition).

"Now my present invention, the results of research and experiments, relates to the production of a new alloy of steel or of melted wrought iron, being a combination of either of the above-named metals with a proportion of nickel which may vary from $2\frac{1}{2}$ per cent. to 50 per cent. of the whole.

"The steel may contain carbon, silicon, manganese, chrome, tungsten or any of the well-known and commonly used ingredients, but I prefer to keep the said materials as low as possible, although in some cases I may increase the carbon. To carry out the invention in manufacture it is only necessary to melt the iron or steel by the Bessemer, Siemens or other like process or by the ordinary crucible process, and to add thereto the required proportion of the ordinary nickel of commerce. The resulting product may either be cast to the desired shape, as an ordinary casting, or as an ingot it may be forged, rolled or otherwise manipulated as desired.

"The metallic alloy so constituted is particularly useful and valuable in the manufacture of cannon, gun-barrels, shot and shell, armor plates, engravers' plates and other articles requiring great strength, a smooth surface or a fine polish.

"Having now particularly described and ascertained the nature of my said invention and in what maner the same is to be performed, I declare that what I claim is: A metallic alloy of steel or iron and nickel consisting of a combination of either of the first two named metals with a proportion of nickel varying (as required) from $2\frac{1}{2}$ per cent. to 50 per cent. of the whole, for the purpose hereinbefore specified."

From enquiry made at Ottawa it does not appear that at the patent office there any patent has been applied for or granted for inventions of alloys of nickel and steel either by Mr. Hall or Mons. Marbeau.

* Journal of the Iron and Steel Institute, No. 1, 1889, pp. 57-8.

† Ib., p. 71.

Possibilities for Ontario.

opening of the New Caledonia mines it fell to that figure from $2 per pound and that five years before the opening of those mines the selling price was $3.25 per pound. The working of the Ontario mines will no doubt effect a still greater reduction, unless the demand should very largely increase as a result of the discoveries of Messrs. Hall and Marbeau. Ten blast furnances, each of equal capacity with the ones now in operation at Sudbury, could produce 5,000 tons of nickel per annum, and from the known extent of the ore ranges a hundred blast furnaces producing 50,000 tons per annum are not beyond the limit of a possible realisation. And having nickel ores and iron ores in great abundance, why should not Ontario aim to produce the world's supply of nickel steel? With skill and enterprise this achievement is possible.

Charcoal iron.

Cost of production.

Location for a furnace.

C. J. Pusey—I have been engaged in smelting works in an anthracite furnace at Pottsville, Pennsylvania, and I believe it would be possible to carry on smelting operations successfully at our own mines in Haliburton if we had a free entrance to the United States. I think we could make charcoal iron profitably, but anthracite iron cannot be made in this country until there is a larger market for pig iron. Neither is the market large enough for a coke furnace. We could make a superior class of castings from our iron, and we could make our own charcoal iron. Our company has been planning a 30-ton furnace. We were advised to put up a 60-ton furnace, but after making very full enquiries we believe that a furnace of that capacity would be larger than our market would warrant. Anthracite and coke iron could not be made for less than $14 or $15 a ton, while the market averages about $18 a ton, and that would not leave enough margin. With charcoal we could make our iron for $3 or $4 less, and have a better market for that iron, and therefore I would not put a dollar into an anthracite or coke furnace and would not advise anyone else to do so. It is a recognised principle in all iron manufacturing countries that if we want a furnace where we can do the work most economically we must plant it where we can place the raw material at the least cost. In Snowdon, for instance, all the raw material is near at hand; if the fuel and ore had to be transplanted to the furnace it would mean so much more added to the cost of production. We have an abundance of wood in our district and could produce hardwood charcoal at 5½ cents per bushel, or perhaps at 5 cents with improved kilns. I consider that it would take about 100 or 110 bushels of hardwood charcoal to smelt a ton of pig iron in a 30-ton furnace. Under date of December 6th, 1881, Messrs. Taws & Hartman of Philadelphia furnished the following estimate:

Estimate of Taws and Hartman of Philadelphia.

We have selected the Howland, Imperial and New York mines for ore for the purpose, and propose using one-third of each, which will give an ore mixture of 59 per cent. of iron. With this mixture the following weights and materials will be required: Ore, 4,000 lb.; charcoal, 2,520 lb. or 140 bushels; limestone, 177 lb. We estimate the cost of a ton of iron as follows:

4,000 lb. of ore at $1.00 per ton	$ 1 80
2,520 lb. of charcoal at 6 cents per bushel	8 40
177 lb. of limestone	10
Labor per ton of iron, including office expenses and superintendent's salary	2 50
Repairs and taxes	1 00
Total	$13 80

Each cord of wood will make 45 bushels of charcoal and the wood will cost $1.30 per cord at the furnace. You will require twenty charcoal kilns to keep up a steady supply of 400,000 bushels per year. These will cost about $500 each, or $10,000 in all. The cost of the furnace we estimate as follows: One cold blast furnace, 8 feet bosh, 40 feet high, with hoist, tackle and cast-house, blowing engine and pipes complete, $36,000. Average capacity of furnace, 100 tons per week.

I believe the above statement is equally as good now as when it was prepared. That estimate was for a cold blast furnace instead of a hot blast, which would make a reduction of $1.50 to $2 per ton. A hot blast would increase the cost of the plant of a 30-ton furnace by about $20,000. The improvements made in the manner of smelting would also reduce the cost. The plant complete for a 60-ton furnace

would cost $135,000. Mr. J. P. Witherow a furnace builder of Pittsburg, Pennsylvania, gave us an estimate in 1884, and his figures for making iron as furnished to me under date of December 15 were as follows : Estimate of J. P. Witherow of Pittsburg.

DEAR SIR,—I have thoroughly examined your letter of the 13th instant, wherein you give me the cost of your ores, limestone and cordwood delivered at the furnace location, together with their analyses, and find that upon the basis of the prices and analyses given you can manufacture iron at the following cost :

2 tons of ore { $\frac{2}{3}$ Howland mine, @ $1.50	$2 00	
$\frac{1}{3}$ Imperial mine, @ $0.50	33	
		$ 2 33
80 bushels charcoal @ $.05		4 00
$\frac{1}{3}$ ton limestone @ $0.75		25
Labor		2 00
Salaries and incidental expenses		50
		$9 08

The average practice of charcoal in the lake Superior region is as follows : The average weight of a cord of hardwood is 3,000 ℔. The yield of charcoal when built in open kilns on the ground runs from 23 to 27 per cent. A safe average would be 25 per cent., making 750 ℔. of charcoal from a cord of wood, equal to 37½ bushels of 20 ℔. to the bushel. This is lower than the general average, as by careful work 45 bushels of charcoal can be made from a cord of wood. Yours very truly, JAS. P. WITHEROW.

The above is the estimate for a furnace of 60 tons daily capacity. We propose now to construct a furnace at the Imperial mine, using equal quantities of Howland and Imperial ores, and with the best data I can obtain the cost of production per ton would be as follows : Another estimate.

5,600 ℔. of ore	$ 2 31
200 ℔. of limestone	0 15
100 bushels of charcoal (1,800 ℔. at 5½c.)	5 50
Labor	2 50
Repairs, taxes, etc	1 00
	$11 46

This estimate is based upon the use of a 30-ton hot blast furnace. While we have not a sufficiency of wood on our own property to carry on the furnace work, we can get plenty of it from the settlers, keeping our own wood to use in case of being disappointed in the delivery of fuel. This would enable the settler to clear up his land at an advantage. Regarding workmen, I may say that the supply of skilled workers is not large in this country and we would have to get men either from the United States or from the old country. Skilled labor is of first consequence, and where failures have occurred in smelting works it will be found that it has been chiefly due to the absence of skilled labor. With experienced workmen I can see nothing in the way of our undertaking the manufacture of charcoal iron in this country. The markets and present prices are satisfactory. One-half of our product ought to be good enough for wheel iron or malleable castings, and the remainder would be suitable for foundry or milling purposes. At present a considerable portion of our ore is waste. The ore of the Imperial mine is too poor to ship, but with the construction of a furnace we could utilise nearly all the ore, shipping the high grade and smelting the low grade. The value of skilled workmen. A furnace would utilise the lean ores

F. E. Seymour—Personally I have had no experience in mining matters, but my father was engaged in the smelting of iron. He came to Madoc from New York state in 1835 or 1836, and I think he began smelting in the latter part of 1836 or 1837. He owned the Seymour mine on lot 11 of the 5th of Madoc, about five miles north from the village. He worked the property for about five years ; the ore was a black magnetite. The furnace did not run steadily and I cannot say how many men were employed. It was a charcoal furnace, and the works were erected in the village of Madoc in 1836 as I believe. The charcoal was made from elm, maple and beech. I cannot give the quantity of ore smelted or the quantity of charcoal required for a ton of ore. I think the iron was at once manufactured into implements, plows, potash kettles and such other things as were then required by settlers. My father had a foundry as well as the furnace, and they began the manufacture of those articles at once. There were several tests or experiments made with the ore, as it required different treatment to that of ores he had been accustomed to in York state ; it contained neither phosphorus nor sulphur. I think smelting went on till 1844 or 1845. The experiments were very expensive, Iron smelting furnace at Madoc. Fasting. Experiments in smelting.

but I think the real cause of the stoppage was a law suit, together with the sudden drop in the price of iron. My father produced very good metal and he said it was a very good ore to work when he got the proper flux. He mixed no other ore with it at all, but put loam with the flux, and this he considered to be the secret of his success.

Joseph Bawden—No attempt has been made to smelt iron ore upon the properties north of Kingston, but I think it could be undertaken successfully. I think the opening up of the iron making industry lies in the direction of using water-gas enriched by waste timber produce from the lumber region. Smelting might be successfully entered upon at some milling point where there is a large quantity of waste material. At the point where the Kingston and Pembroke railway crosses the Mississippi there is an unlimited water power, and there is an immense quantity of what is now looked upon as waste material that would answer for the purpose of manufacturing charcoal and carbonising water-gas, and thus give us means of making iron as cheaply as at any other place in the world. The use of sawmill refuse for smelting iron from the ore has been carried on in Sweden. I do not know that it has been used in connection with water-gas, but it has been for making charcoal. The water-gas would have to be made as a second product in the manufacture of gas from coke. It is made by injecting steam over the coke undergoing combustion, and then it is enriched either by the use of petroleum or gas made from the waste products of the mills. I understand that Nova Scotia slack coal has been landed here at $2.75 a ton this year, and American coal at $3.35, including duty I think. The duty would be to that extent against the use of American coal. I do not think that legislation can do anything to help the iron industry, but I think we might import the skilled knowledge which we have not got here. If we had the aid of experts acquainted with similar mineral-bearing formations in Europe where there are similar conditions to deal with, as for instance in Sweden and Norway, it would be of the greatest advantage to us. I think that works could be established at some milling centre where charcoal could be manufactured out of the refuse and used in the smelting. Charcoal pig iron, cold blast, commands the best price and there is always a steady demand for such iron if of high class. The tariff is no barrier against high class iron, and we could make the best of iron in this country. Such an establishment should have a furnace of 15 or 20 tons a day. There should be a foundry for iron from ore not suitable for first class pig. The open hearth system could be used for scrap iron in connection with the ore, and to operate that we could have the gas from the refuse not made into charcoal. I think the prospects of profit from such an establishment are very good. Some years ago some of us here considered the cost of smelting with coal, but my opinion is that we could not enter upon the smelting of iron at Kingston with American or Nova Scotian coal with economy. I do not think that even if we had the American tariff it could be done here. We can ship ore cheaper from here than it can be shipped from the lake Superior region ; the difference is about 75 cents a ton in our favor. My opinion is that notwithstanding protection I do not think we could econmically smelt iron ore in Kingston. My interest would lead me to wish a different conclusion very strongly. I am referring however simply to smelting. I do not think it would be impossible to manufacture iron by the open hearth process even without the aid of the tariff ; much more with the aid of the tariff. But the whole question of the proper development of iron manufacturing in this country should not turn simply upon either smelting ore or making steel by the open hearth process. We should endeavor to establish the industry in all its various branches as well as smelting. One of the principal factors in iron making is power to crush the refractory ores cheaply, to separate them from certain impurities that yield to certain processes, etc. Power is also an element in the preparation of wood fuel, and is a valuable factor in working a rolling mill. In the region crossed by the Canadian Pacific railway are the great water powers of the Mississippi and the Madawaska rivers, which could be used as I suggest. The government should secularise the power of those rivers. Their navigation could be improved so as to make them useful for bringing ores down as well as fuel. When the rivers are dammed and the power created, the manufacturing rights could be leased on favorable terms to any who desire to enter upon the manufacturing of iron. We understand something here about the preparation of charcoal, having paid $40,000 for our lesson, and we found out that we could not make charcoal by the process we had at a price to enable us to make iron. The cause of failure was perhaps more to be attributed to the way the works were laid out than anything else. They were not so laid out that the foreman could have them all under his eye and watch the working properly. I

Water gas and charcoal as fuel for smelting iron ores.

Production of water-gas.

Skilled knowledge is necessary.

Cold blast charcoal pig iron.

The open hearth system.

Utilising water-power for treatment of ores.

A lesson in charcoal making.

think the bye-products should be a source of profit. When we started to work the acetate of lime was four cents a pound; it then fell to three-quarters of a cent a pound, and of course at that price it could not be made at a profit. Had we put in a plant for the manufacture of acetic acid we would possibly have been successful. The profit on the manufacture of wood spirit is considerable and would have been a large source of revenue had the works been otherwise economically managed. Cordwood was $2.50 and one cord gave 64 bushels of charcoal. We cut our own wood and it cost us more than that; we could have bought it a good deal cheaper. We could make charcoal cheaper by the retort process; we could make it now I think at seven cents a bushel. As far as the quality of the charcoal was concerned we turned out an excellent article, and it was pronounced by the Locomotive company the best they got anywhere. If we could make the charcoal at seven cents a bushel we could smelt and make money. By a proper system the bye-products could be largely made to pay for the process of manufacture, and perhaps leave the charcoal free of cost, or nearly so. In the state of Wisconsin it is manufactured and taken a long distance for use in iron works. At Binghampton the retort process is used for making wood spirit and acetate of lime, and the charcoal is sold for local consumption as fuel. I believe charcoal could be made on the Madawaska and Mississippi in large quantities. What mill refuse was not used in the manufacture of the charcoal could be utilised for enriching water gas for use in the open hearth process and roasting the more refractory ores. A Pittsburg gentleman told me that water-gas could be made at three cents a thousand feet; you can enrich it either with gas made from wood or with coal gas. We might use Nova Scotia coal for making coke and for gas to be used in enriching the water-gas for roasting our refractory ores, and for use in the open hearth process if free from sulphur. A good hard charcoal is required for smelting. For the finery fire a soft charcoal is better. Patents have been taken out for smelting with gas, but I do not know that they are in successful use. In what are called the direct processes for reducing the ore, gas fuel is used altogether, and these processes in point of economy are superseding all other means of economically manufacturing rich magnetic ores like ours. Preparation of the ore by roasting for desulphurising and making it 'kindly' or 'mellow' is essential to the successful treatment of this ore by the open hearth process. It is best to use the natural resources of the country where they are of a permanent nature, or where they can be made so by wise legislation; this I look upon as better than any tariff, which is purely artificial. The best thing to do is to stop the region watered by the Mississippi and Madawaska from being a free grant district. The land is poor and all the timber is being burnt off it. That should be stopped once it is shown that the iron industry can be successfully carried on, relying on the natural resources of the country. We should learn by the experience of other countries, and copy the system that has been found to work well in Norway, Sweden and Austria. In exporting, nothing but the best ore is taken, nothing less than 50 to 60 per cent., and a great quantity of ore is therefore thrown into the refuse heap It has been found in some instances that the refuse matter will average 30 per cent. iron. If there were works in the neighborhood of the mine all this refuse might be saved, and we require cheap as well as high priced iron.

Charcoal from mill refuse.

Gas fuel in the direct process.

Utilising the natural resources of the country.

Waste of ore in exporting.

B. W. Folger—I do not think smelting could be profitably carried on in the neighborhood of the mines. Canada is not big enough to take the output of a furnace, and the duty is just high enough so that it would come in anyway. If the duty were higher they could make it. I think it should be $2 higher; if we had that much higher duty then iron could be manufactured here. I am referring to getting the coke from the States. I do not think it could be carried on at all and get the coal from Nova Scotia. If there was a bonus of $1 or $1.50 a ton more it could be done. I never made an estimate as to the price of making pig iron, but the Kingston and Pembroke Mining company figured it out. They were figuring on getting the coke from the States, and it was estimated that the iron would cost about $17 a ton—from $15 to $17. If the bonus is raised by $1.50 or $2 a ton I will start a furnace here in less than six months; of course there would have to be a guarantee against the lowering of the bonus or the duty for a number of years. American pig iron sells all the way from $16 up to $22 according to quality. There was some made last year that sold at $15 a ton, but that was poor iron from poor ore. The American duty is $7 a ton on iron and $14 a ton on steel rails. We cannot make it as cheaply here as they do in the States. A bonus would be better than an extra duty to encourage the iron business here. I think if the Ontario government had given a bonus a few years ago there would have been thousands of tons made in Canada, and there would have been thousands of tons mined where now

A higher duty needed to encourage the smelting of coke iron.

Cost of producing coke iron.

Selling price of American pig iron.

A bonus better than a tariff tax.

there is not one ton. If the Ontario government would give a bonus equal to that offered by the Dominion government a furnace would be started even if the duty were not raised, rolling mills and other factories would follow, and thousands of people would be employed. It would facilitate the manufacture of many articles that are imported now, and I think it would make iron cheaper in the course of time. If we could smelt ore here we would have the market of this country, and that is a great deal ; besides, a great amount of ore would be shipped to the States. We could have sold 50,000 tons from the Wilbur mine if we had it this year. I do not know of anything that would help more to develop the mines of Ontario than the starting of a blast furnace at some place between here and Toronto ; and I may say that I think it can be manufactured at Belleville or here a dollar a ton cheaper than in Toronto. I think it would do a great deal of good also if the Ontario government gave a small bonus on getting out hematite ore. If smelting works were started there would be no difficulty in getting a sufficient quantity of ore. The miner should receive some help to get what there is under the earth. The lumberman can see what he is going to get for his money and labor, yet he has been helped. Money has been spent by the government to improve the streams for his use. A bonus to start a furnace would create a great industry.

A smelting furnace would promote mining operations.

Aid for the miner.

William Rattle—I live at Cleveland, Ohio, and by profession I am a mining engineer and analytical chemist. All the iron deposits that I have examined in the region north of Kingston dip to the south-east, and the strike is north-east and south-west. The sulphur in some cases in Lanark county occurs all through the mass, which is so close grained that the gases cannot escape. In Norway the ores are of a spongy nature, and the sulphur occurs in cubes in the spongy mass ; the sulphur is therefore enabled to escape. The ore on the Levant property is badly mixed all the way through. It could be calcined if put through a crusher, but that would be necessary. In the district I visited I do not believe there is any sulphur in the ores. I believe you have a magnificent outlook for iron. I am of opinion that where the limestone predominates the sulphur and titanium disappear, but where deposits are strong in iron there is apt to be sulphur, titanium and phosphorus. I have been intimately connected with the smelting of iron since 1872. I think these Ontario ores would be easy to smelt, as much so as our ores from lake Superior. For the smelting of ores here I think the best place to bring fuel from would be the Connellsville district of Pennsylvania. There is ample flux in the immediate vicinity. I think you have ample supplies of ores here to make the best quality of steel rails, and in sufficient quantities to warrant the starting of a blast furnace. A furnace with a capacity of 100 tons a day would be about the most profitable ; I mean one that would produce 100 tons of pig iron a day. It should have all the modern improvements. A furnace which I built at St. Louis of that capacity cost $135,000 completed ; that gave us $15,000 capital over and above the cost of the furnace. The cost of the furnace was really $120,000. You would have to import coke and fire brick ; that is about all you would require to import, and you would require about $25,000 for fire brick. Our limestone in St. Louis for flux costs 60 cents a ton ; in Ohio it costs 80 cents a ton. It is poor work when we use over 30 per cent. flux ; that reduces the cost per ton to 25 cents. The ores here carry lime largely, and I do not think you would require very much flux ; those that I have examined carry from 5 to 8 per cent. lime. You would therefore not have to use as much flux as we do in the States, where the ores do not carry any lime. All the soft hematite ores should carry a great deal of lime, as they are in the lime bed. At the present rate of freight coke would cost you about $5.50 laid down at Kingston, that is with the duty. With improved stoves you would only use a ton of fuel to a ton of metal. Then put the cost of ore at the rate of $4 for a ton of pig, labor $1 a ton, wear and tear and interest 50 cents, limestone for flux 25 cents per ton of metal,—that makes $11.25. It would not be more than $12 a ton anyway ; all over and above that would be profit. It is said that old country people can lay it down here at $10 a ton and make a profit on it ; if that is so you cannot compete against them. If a bonus were granted by the Ontario government it would make it a matter of interest to come here and put up a furnace, otherwise I do not see how you can induce people to go into it. Once established I think it would be a permanent industry, but it would take some inducement. In Cleveland it costs $14.85, or about $15 in round figures today to produce a ton of pig. The ores I have seen in this country I do not consider very refractory. I do not think they will take more fuel then we use for a mixture of one-quarter of the Republic and one-quarter of the Gogebic ores. I do not know anything about your market here, but I am satisfied that I could make a good quality pig from what I have seen ; and

Close grained ores containing sulphur require to be crushed.

Cost of smelting plant.

Cost of producing pig iron.

from what I have seen I am satisfied there is ample in sight today to warrant any one in putting up a blast furnace. I am perfectly satisfied that a blast furnace would have no difficulty in getting all the ore it wanted. I understand the Dominion government gives a bonus of $1.50 a ton; there must be some other inducement besides the duty and that bonus. You must have a high duty before you build your furnace. I was manufacturing pig iron at St. Louis, selling it at $23 a ton, and making a handsome profit. All of a sudden the market was flooded with English pig iron brought up the river from New Orleans. Unless you have high duties here you cannot make your industries thrive or make yourselves independent. Here is the difference in the labor: a wheeler will wheel a hundred tons in the United States and it costs $2.75, in England it will cost $1. There must be a duty, or a bonus high enough to shut out both England and the United States. Scotch pig in Cleveland sells at $21 after paying the duty of $7. I think a margin of $6 should be ample encouragement here. I am not in favor of charcoal iron for this part of the country. You require several kinds of ore, and with a blast furnace you make No. 1, No. 2, No. 3, and with rolling mills and foundries you can use up all the iron in connection with the furnace. There is the largest charcoal furnace in the world at Black River Falls, and it is a failure. The idea that the bye-products will pay for making the charcoal has been always a failure. It would cost 5 cents a bushel, and it would take about 125 bushels to smelt a ton of pig; that is equal to $6.25 a ton.

Protection and bonus.

Charcoal iron.

W. H. Wylie—Judging from engineers' reports I think iron could be smelted in this country if there was a sufficient amount of capital, and if the works were managed by business men. If such works were put up in the back country charcoal would have to be used; there is plenty of wood for that purpose. I had Mr. Birkinbine of Philadelphia make a report for us, and the total cost of production according to his calculation would be $12.85 per ton. I do not know anything about the cost of producing charcoal, but I think if works were established a great many farmers would be induced to go into making it.

Estimate of cost of charcoal iron

Wm. Caldwell—I think iron could be smelted here to a certain limited extent. We made a calculation some years ago, and the conclusion was that if a sufficient inducement was offered by the government works would be established. It could be either charcoal or ordinary coke smelting. But before anything can be done it will be necessary, so as to induce people to put money into it, that a bonus be given for a term of years—say five years. I do not remember what the figures were when we went into the calculation, but we thought if the Ontario government gave a bonus of $2 a ton and the Dominion the same for five years it would be all that was wanted. The bonus should be given only to the first, or first two establishments that were started.

Encouragement of iron smelting by government bonuses for a term of years.

H. H. Wallbridge—My brother was thinking of starting a five-ton furnace and we went to Sweden to see how they manufactured charcoal iron there. We came to the conclusion that we have better opportunities to manufacture charcoal iron here than they have in Sweden. We are in a better position; we have hard wood, while they have but pine. I saw the operation of smelting in Sweden but did not ascertain the cost. At the time I was there, in 1869, they were exporting iron all over Europe and were importing English iron. One or perhaps two furnaces might do well in this country, either charcoal or coke furnaces; the coke could be brought across. For charcoal iron there is plenty of wood, and we have better facilities in every way than they have in Sweden. I really never considered the question of smelting here with coke, but I do not think anything will be done with our mines till the American duty is taken off.

Charcoal iron manufacture in Sweden.

E. W. Rathbun—If smelting works were established here we could supply the necessary charcoal at from six to eight cents a bushel. Our kilns for making charcoal are shaped like the old fashioned beehive; the capacity of each kiln being about fifty cords of wood. The vapors which pass over are separated, the condensable are liquified, while the gas which cannot be condensed is carried back to the kilns and used for carbonising the wood or generating power in connection with the works. We waste nothing. From a cord of wood we get fifty bushels of charcoal, four coal oil barrels of liquid and from 800 to 1,000 feet of gas. If all these products are weighed it will be found that we have lost comparatively nothing. For two years we lighted our works with gas made from sawdust, which makes a fair illuminating gas, but the treatment required is somewhat intricate as compared with coal and oil gas, so that now we prefer to make the latter for illuminating purposes. We produced sawdust gas at 12½ cents per 1,000 feet. From the liquid

Cost of charcoal for smelting iron ore.

Bye-products.

produced in our wood distilling works we get wood alcohol, acetate of lime, sugar of lead, etc. We also make different kinds of liquors used in dyeing, etc. The Dominion government takes the wood alcohol and uses it in mixing with grain alcohol for mechanical purposes so as to prevent frauds on the excise. Utilising the bye-products cheapens the production of the charcoal. We have eight kilns, but it would require about twenty kilns for an iron smelting plant. I think iron could be smelted profitably with charcoal at 8 cents a bushel. Charcoal varies in weight from 16 to 20 and sometimes as high as 22 and more pounds per bushel. The acetate of lime is chiefly exported to England. The bye-products can, we think, be utilised in this country. We have had some estimates as to the cost of making charcoal iron, and I think it is practicable to make our own charcoal iron in Canada. I have no doubt but that it could be manufactured at a profit, and I think Deseronto is favorably situated for the starting of that industry. The distance to haul the ore is not great and the freight cannot be much; there is plenty of flux, and the shipping facilities are of the best. There is no reason to prevent charcoal being manufactured for a time as cheaply at Coe-hill as here if works were once erected there of the proper character. I would not undertake to produce charcoal here at 7 or 8 cents a bushel without taking into account the bye-products. We can supply charcoal sufficient for two 15-ton furnaces. I understand some furnaces of that capacity are producing iron as low as $14 per ton. With our system I should advise a plant running up to a minimum of 20 tons a day, and 20 to 25 kilns would supply the charcoal for it. We could surely supply one furnace anyway, and if any point in this section of country could sustain two this is the place I think. The cost of making the iron can no doubt be figured out pretty accurately. I believe there is charcoal iron enough used to keep more than one furnace going, but I have not gone into the details closely. Charcoal blooms could no doubt be manufactured with reasonable profit. I cannot say whether further encouragement in the way of duty or bonus is required to induce the starting of smelting works; I have been under the impression that the government was very liberal in the matter of encouragement to iron smelting. The matter has not been a question of vital importance to me, and I do not wish to give an opinion on a matter I have looked into so little.

Charcoal iron.

Home market for charcoal iron.

Thomas Ledyard—I have a letter from a high authority who resides at Pittsburg, Mr. J. P. Witherow, in reference to the cost of manufacturing charcoal pig in such a place as the old Belmont mine. He made out that the pig could be produced inside of $10 a ton; that is the actual cost. He estimated the necessary capital of the company at $150,000, the plant of which would include a Clapp-Griffiths converter capable of producing steel at $14 a ton, and he put the price of the charcoal at 6 cents a bushel. If we had free trade with the United States I do not see why Toronto should not be an excellent point for a coke furnace. The principal cost is in the ore; less than a ton of fuel will make a ton of pig. We want the American market; there is no encouragement to put up large and expensive works for such a small market as that of Canada. Mr. Mills of Michigan says that to his knowledge three blast furnaces would be started in Canada as soon as the American duties were removed. If we had free trade we could manufacture iron here cheaper than in the States. We could deliver the ore at Toronto, supposing the company to own the mines, at $2.25 per ton—$1.50 to mine it and 75 cents for freight. If the furnace proprietors did not own the mine then 50 cents per ton would be a fair royalty. In Chicago good Bessemer ore is $5.25 to $5.75; they use Connellsville coke, and I think it could be delivered here a little cheaper if there were no duty. With the fuel as cheap and the ore at half price we should stand a good chance if we had the same market. The great difficulty to contend with here is the English competition.

Cost of manufacturing charcoal iron.

The United States market necessary for the industry in Canada.

Thomas Shortiss—In 1872 my partner and myself examined lot 20 in the 1st concession of Snowdon; it looked well and we bought it and opened it up. Ore was afterwards taken out and shipped to the States, but the duty killed the trade. Tests by the diamond drill showed over half a million tons of ore at this mine. I induced Messrs. Parry and Mills to look at this property; they tested with a drill to a depth of 300 or 400 feet and were well satisfied. They erected smelting works, but as everything was about completed they ran out of money. Every effort was made to induce people to advance $10,000 upon the security of the property, but no one could be got. Our people do not believe in the country; they do not believe that our ores will smelt into iron at all. If Parry and Mills could have got $10,000 the furnace would have been started; all they wanted was the money to line the furnace, but they could not get a dollar. At the time the endeavor was made to

An unsuccessful attempt to set up an iron furnace in Snowdon.

get the $10,000 on the security of the property there was between $50,000 and $60,000 invested. Charcoal iron could be made at $12 per ton. I will furnish you with Mr. McCorquodale's letter on the subject. He is the manager of large smelting works in Michigan.* I think the present protection and duty are ample. There is plenty of ore and it is good enough, but taking it altogether it is lean, from 52 to 54 per cent.; that is rich enough for furnace purposes. We could undersell English iron and there would be a good market in Canada for it if sold cheap enough; but in addition we want the American market to sell our ores. We could use up our poor ores and ship our high grades to the States. If the Ontario government would start a smelting furnace it would show what could be done with our ore. Such a furnace should be erected where there is both ore and timber. The cost would be about $100,000. Charcoal could be made for four cents and it would be ready money for the settlers.

Cost of producing charcoal iron.

A government furnace to demonstrate the enterprise suggested.

George A. Shaw—I was connected with an iron enterprise in Marmora some years ago, and we tried to smelt ore with petroleum, but we could not get any fire-brick that would stand; that is about seventeen years ago.

Petroleum as furnace fuel.

T. B. Campbell—I do not know anything about the cost of charcoal smelting, but I think the country in Victoria and Haliburton is well adapted for that business. There is plenty of wood, flux and ore, and it would be safe to say that hardwood could be obtained at $1.50 a cord. Take a selected 5,000 acres and it would yield about twenty cords of wood to the acre. It would require a large area to keep a furnace going twenty-five or thirty years.

A favorable region for charcoal smelting.

Henry Graham—It was the intention of Parry and Mills to use both hard and soft wood in the manufacture of the charcoal. There are considerable quantities of beech, maple, birch, hemlock and elm and a little poplar in our district. I think the calculation they made was, that it would cost about $16 a ton to manufacture the iron—that is, calculating to bring part of the ore in to make sure of a supply. Parry and Mills thought, if they could get 5,000 acres of wooded land, that this with what they could get from the settlers would ensure them a supply. This industry would be a great advantage to the settlers who are a distance from the railway, as they could make charcoal from their wood and sell it, instead of now having to burn up the timber. Those near the railway can sell, and it is shipped to Toronto. A good deal of wood is being burned in the clearing up of the country; half of it is too rough for the city, and that could be made into charcoal.

The Parry and Mills undertaking.

Value of the smelting industry to settlers.

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*At the date of writing Mr. McCorquodale was superintendent of the Jackson Iron company's furnace in Delta county, Michigan, and had held that position eight years. Under date of April 8th, 1885, he wrote Mr. Shortiss in reference to the contemplated erection of a smelting furnace in Haliburton as follows: "Should the furnace be erected in or near Snowdon it will make a big boom in iron mining. We are running our stock here, making 50 tons of iron per day, with a consumption of 112 bushels of charcoal per ton—half soft wood coal. With all hardwood charcoal we can make iron with 95 bushels per ton. Our coal costs $7.05 per 100 bushels and we haul it an average of eight miles—the greatest distance to haul being twelve miles and the shortest four. Our iron costs $17.57 per ton, as follows: Ore, $7.75; charcoal, $7.90; limestone, 25 cents; labor and office expenses, $1.67. Our ore yields 62 per cent. and takes a little over $1\frac{1}{2}$ tons to make one ton of iron. With the Snowdon ore, which if I remember averages 55 per cent., and with hardwood charcoal, I am satisfied that iron could be made at $12 per ton, or say:

2 tons of ore at $2.50	$ 5 00
100 bushels charcoal at 5c	5 00
Limestone	0 25
Labor and expenses same as here	1 67

Making a total of $11.92. I am sure the ore will not cost $2.50 delivered at the furnace. Coal can be had for less than 5c. per bushel; we do it for that here and haul the wood from three to four miles. It is the long haul from the most distant kilns that runs the price up to 7c. or a fraction over. It will require 35,000 to 40,000 tons of ore to run a furnace for a year, and that will open up a great many mines. . . I have just looked up the stock book and find that our ore costs us here $4.84 per ton." Under date of May 3rd, in the same year, Mr. McCorquodale wrote a second letter from which the following extract is taken: "The country in this locality has much the same general character as in Snowdon. Only the shores of the lake and bay had any settlers before this company started, and they made fishing their business. Since then, as the wood was cleared off, settlers have come in and they raise coarse crops, such as potatoes, turnips, hay and oats, all of which is purchased by the company during the winter. Those settlers turn out and cut our wood, for which they are paid cash or trade in the company's store, as they please. Our wood for the year is all cut now and the settlers are starting to work on their farms. We are paying 60c. per bushel for potatoes, for which if the furnaces were not in operation they could not get one cent. Our average monthly payments per annum are for all kinds of work $7,661; for wood cutting the average is $1,317 per month. As I remarked, if the furnaces were not in operation the farmers could get sale for nothing; in fact they would be compelled to leave or starve."

Coke and charcoal for fuel.

Arthur Harvey—In reference to the smelting of iron, there are two ways of doing it—on the front with coke, or in the back country with charcoal. There is a new system in use in Russia for the manufacture of charcoal iron. It appears to be the most economical and best way yet devised. Mr. James Lobb has corresponded with some parties in Russia about the matter and can show you the letters.

Polished Russian sheet iron.

James Lobb—I am a commission merchant residing in Toronto. I deal in metal to some extent. I produce correspondence with some Russian parties for whom I am the Canadian agent in reference to charcoal iron. Polished Russian iron is worth £28 10s. a ton, delivered in Montreal. The retail price is about 11c a pound. It is used for the best class of stovepipes and small stoves. I am informed by an expert that the manufacture of sheet iron of the same quality as the Russian sheet iron by the use of the Husgafvel furnaces would be quite feasible here, the deposits of iron ore in both countries being of the same character.

A charcoal iron estimate.

A land or timber subsidy suggested.

H. S. Howland—I do not see why it should not pay to make charcoal iron. Speaking from memory the cost of making it, as stated by experts, would be $14 a ton. That is supposing the works to be erected at Snowdon, where there is plenty of wood. That is the short ton and does not include bringing the ore any distance; but I understand there are two kinds of ore that would suffice to mix. The men who made the estimate had been manufacturing charcoal in Michigan. I think it would be wise to make a grant of land or timber to a charcoal furnace, or to do something that would induce capital to go into it. There would be a limit to the market, but I think charcoal iron would to a great extent take the place of other iron.

Prussian and Swedish estimates.

The Hull furnace.

Lead smelting.

Frederick Miller—When I first came to this country, some years ago, I drew attention to the cost of smelting iron here as compared with Sweden and some parts of Germany. I extracted a large amount of information from the report of Mosler to the Prussian government in 1865. The cost in Sweden and some parts of Germany was $10 and $10.50; here $13. In Sweden the wood they have is jackpine and birch, the principal wood being jackpine. There they used 117 bushels of charcoal to the ton. In the Hull works, near Ottawa, I think they estimated the cost at $21 or $22, but they used 225 bushels there to make a ton. Their furnace was not properly built. If there is plenty of charcoal to be had, and if the ore is handy to the mine, I think under present circumstances it can be produced in Canada for $14 a ton. I believe there is a great future for the mining industry of this country. The lead-smelting has been neglected. I have had many years' experience in that line in Germany and I think it could be worked to great advantage if we had the capital. One of the great causes of all our failures in this country has been stock-jobbing.

Iron mining and smelting should succeed the lumber industry.

John A. Barron—I reside at Lindsay. I think it is a most important matter that something should be done in the interest of the back country to develop the iron mines. The land in the back country is but fairly good and the main dependence of the settlers has been on the lumber. That is about exhausted now and cannot be counted upon any longer. The development of the iron industry would support an intelligent and thrifty population. There is a very large quantity of wood being wasted that would answer to make charcoal, but plenty is yet left for that purpose.

Caution advised.

R. E. Bailey—It is well to be cautious about erecting expensive works and machinery till the property has been thoroughly explored; many failures have resulted from too great an expenditure at first. As far as Americans are concerned, if they were satisfied it would pay them better to mine here than in the United States, I think with very few exceptions they would come over; with them it is a mere matter of business.

Government aid for iron smelting works.

A. J. Cattanach—I think the government should assist in the erection of smelting works—iron smelting works. The best way to do that would be by grant to responsible people. Personally I do not know anything about smelting, and therefore cannot say whether the present bonus and duty are sufficient protection.

The Canadian iron trade.

J. H. Bartlett—I reside in Montreal, but was born in England and educated there as an engineer. I am a member of the Iron and Steel Institute, of the Institute of Mechanical Engineers and various other engineering societies on this continent and in England. I have lived in Canada for the last 17 years and was for some years managing director of the Toronto Bridge works. I know the provinces of Nova Scotia, New Brunswick, Quebec aud Ontario, and have been in Prince Edward island and Manitoba. For the past four or five years I have made a special study of the Canadian iron trade. In 1885 I published through Messrs.

Dawson Bros. of Montreal a pamphlet of 167 pages on the Manufacture, Consumption and Production of Iron, Steel and Coal in Canada. In that work an account of every attempt to manufacture iron in Canada is given, together with statistics of the Canadian iron trade in great detail. These statistics have been accepted by the Dominion government as their standard authority on this subject. After a short account of the processes in the manufacture of iron I go on to show how all the countries of the world which today are iron producers have succeeded in establishing this industry. I was led into the study of the subject gradually at first by having to make a professional report in 1883 on some deposits of iron ore with a view to the manufacture of iron and in order to ascertain if the erection of iron works was advisable. Enquiry was made as to the extent of the domestic consumption, but satisfactory information was not obtainable, the only official publication being the trade and navigation returns of the Dominion. It required a very considerable amount of patience and perseverance to extract the desired information, and having by this time become thoroughly interested and impressed with the importance of the subject to the Dominion generally my labors were continued with the result before named, and the sequel is seen in the recent changes and readjustment of the Canadian customs duties on iron. The provinces were confederated in 1867, but until 1879 pig iron was admitted free of duty. The failure of the various attempts to make charcoal pig iron and blooms is clearly attributable to the want of protection. Many of the attempts were made early in the century and the operations were of the smallest dimensions, but both in Ontario and Quebec this industry flourished in early days until competition with imported coke pig iron made it impossible. Iron rails have been rolled both in Toronto and Hamilton, but the change to steel rails and the lack of protection has closed that branch of the trade. A considerable trade is done in Canada in re-working old material, and there are now a number of rolling mills in various parts of the country which re-work scrap. This no doubt is a step in the right direction, but the real prosperity of the country will not be achieved until the iron we consume is largely produced from minerals dug out of Canadian soil. Only one attempt has ever been made to manufacture coke pig iron and bar iron out of Canadian minerals, and the possibility of doing so has been proved. The quality of the article in both cases is superior to that imported and commands a higher price, and it is very satisfactory to know that since the adoption of the new iron duties this one company, now the Londonderry Iron Co., has had all the work they can do. The following figures show the imports into Canada for home consumption :

The customs duties on pig iron.

Charcoal iron.

Coke iron.

Canadian consumption of iron.

Year.	Value.	Year.	Value.
	$		$
1868	6,885,365	1878	9,398,306
1869	7,385,780	1879	7,962,295
1870	7,750,867	1880	10,128,660
1871	10,808,645	1881	12,955,855
1872	15,913,179	1882	17,499,488
1873	25,435,020	1883	20,080,274
1874	20,700,387	1884	14,790,727
1875	18,199,198	1885	11,415,713
1876	12,965,117	1886	11,053,365
1877	11,082,321	Total....	253,210,512

Out of this amount $158,330,882 had to pay duty and $94,879,630 was admitted free. The importance of the manufacture of iron to the country will be appreciated when it is shown that the total balance of trade from 1868 to 1886 amounted to $381,000,000 against Canada, and that during the same period we imported 253¼ million dollars of iron and steel goods.* I prepared at the request of Sir Charles Tupper a series of diagrams from my statistics showing graphically, first, the invoice

The balance of trade.

* The so-called balance of trade against Great Britain and Ireland for the same period (1868 to 1886) was £2,807,284,325 sterling; against France £477,710,000; against Belgium £200,318,000; against Sweden £48,013,000; and against Germany in the ten years from 1877, when values began to be given, £126,028,000. And these are the principal iron-making and iron-manufacturing countries of Europe.—A. B.

value of the imports of iron and steel; second, the balance of trade against Canada and the proportion thereof due to iron and steel imports; third, the consumption per capita of the population of iron and steel imports; fourth, duties paid per capita on these imports; fifth, total consumption of coal in Canada; sixth, total production of coal in Canada. These diagrams were distributed to members of the House of Commons at the time of the delivery of the Budget speech in 1887 and are published in the appendix to the speech. Sir Charles Tupper stated, and I am convinced that the figures he used had been very carefully prepared and were correct, that apart from steel rails our present consumption was equivalent to 250,000 tons of pig iron per annum; this in my opinion is safely within the mark, and would require ten blast furnaces of good size for its production. But this is not all foundry iron, only 25 to 30 per cent. of this quantity being required to take the place of iron now imported especially for foundry purposes. I mean by a good size blast furnace one to make 100 tons per 24 hours, or to average 25,000 tons per annum. This is a much higher average than the blast furnaces in England, where in the year 1882 there were 570 furnaces in blast and 385 out of blast. The 570 furnaces made 8,500,000 tons of pig iron, or an average of 15,000 tons per furnace. On this basis it would require 16 blast furnaces to provide for the Canadian market. In the statistics I prepared the imports of iron and steel for home consumption are classified under seven heads, which in a general way represent the amount of labor expended upon the material. These are: (1) Iron, which includes scrap, pig, blooms, puddled bars, merchant bars, rolled shapes, plates, sheets, hoop, band, wire rods, wire and tubing. (2) Steel, including ingots, bars, rods and sheets. (3) Rails, including rails steel and iron, frogs, etc. (4) Castings and forgings. (5) Cutlery and edge tools. (6) Hardware and manufactures. (7) Machinery and engines. The average weight of finished goods classed under the first three heads, viz., iron, steel and rails, for the ten years 1875 to 1884 amounted to over 200,000 tons per annum. Under cutlery and edge tools are included many other articles such as axes, scythes, hoes, rakes, forks, spades, shovels, files, rasps, etc., most of which are now made in Canada out of imported iron or steel. It must be borne in mind that all the articles are derived originally from iron ore, and by the application of labor and fuel they are gradually converted stage by stage into the finished article or machine; at every stage there is also a considerable loss of weight. The equivalent in pig iron is the original weight of pig iron required. For the seventeen years 1867 to 1884 the totals of imports by classes were: Iron, $75,179,153; steel, $9,938,614; rails, $48,068,618; castings and forgings, $9,703,717; cutlery and edge tools, $10,742,331; hardware. etc., $47,926,637; machinery and engines, $29,182,414,—making a total of $230,741,484. The valuations are the invoice values at the place of manufacture and shipment, and do not include anything for freights, charges or duties. The item of freight alone is a very important one, as from four to five tons of minerals are required for every ton of pig iron made, and pig iron is the first process or raw material for all subsequent processes. I am interested in some extensive deposits of iron ore in the county of Pictou, Nova Scotia. The conditions there are very similar to those at the new iron centre in the United States, viz., Birmingham, Ala., except that Pictou is right on the Atlantic tide water, while Birmingham is 350 miles distant from the sea. The situation at Pictou combines a railway centre and good navigable tide water, a well settled cultivated country with good roads and plenty of labor, four varieties of iron ore in very large deposits occurring only about six miles from the Pictou coal field, from which half a million tons of bituminous coal are mined annually. In addition there is an abundance of limestone, besides gypsum, freestone, sand, brick-clay and fire-clay. Mr. Selwyn, director of the Geological Survey of Canada, states that Pictou county is as favourably situated as are the best iron producing districts of Pennsylvania, and that it presents greater facilities for manufacturing iron profitably than are to be found in any other part of the Dominion. When in England last spring I interested some very prominent and wealthy men connected with the iron trade there, and they would have taken the matter up and invested £300,000 in a large plant for the manufacture of pig iron and steel rails provided a duty was imposed on the importation of steel rails and an order for a certain quantity guaranteed. I laid the matter before the Dominion government, but they were unable to see their way to any arrangement and the project was not carried out. Steel rails are now and have always been free of duty. Since 1867 Canada has spent about $50,000,000 for rails alone, and the people of Canada have contributed during that time $165,000,000 to assist in the construction of railways. It seems reasonable to suppose that the country would have been better off if this amount of money for rails had been spent in wages in Canada. In the United States when railways have been subsidised by the government it has been specified that the rails were to be of

Present consumption of pig iron.

Classification of iron and steel imports.

Values of imports by classes.

Situation of the Pictou iron mines in Nova Scotia.

A project that was not carried out.

American manufacture, and in some cases not only the rails but all the other iron used in the construction and equipment. The Union Pacific the Northern Pacific, the Atlantic and Pacific and the Texas Pacific had to use American rails. In Canada we have now about 13,000 miles of railway, but no rails are made. No other country in the world can make such a showing. In all cases other countries have succeeded in establishing iron industries by protective duties, bounties and subsidies or concessions. Take England for example. In the year 1800 she produced 130,000 tons of pig iron; in 1850 this had increased to 2,500,000 tons. Now let us notice the protective duties which were in force from 1800 on such an article as bar iron. In the year 1802 the duty was $18.35 per ton; in 1803, $20.52; 1804, $21.19; 1805, $24.75; 1806 to 1808, $26.15; 1809 to 1812, $26.72; 1813 to 1818, $31.59; 1819 to 1825, $31.63 if imported in British ships, but if imported in foreign ships $38.56. Iron slit or hammered into rods less than three-quarters of an inch square, $93.33 per ton; wrought iron not otherwise enumerated for every $486 of value, $243.33 per ton; wire not otherwise enumerated $577.92 per ton; hoop iron $115.58. In 1826 these duties were reduced and in 1848 were abolished, but in the meantime the industry had grown to such an extent as to control the iron trade of the world. All other countries have the same tale to tell. In the United States, France, Germany, Belgium, Russia, Italy, etc., the governments have recognised the vital importance of this industry to the welfare of the community and have taken such steps as have been from time to time found necessary to ensure its growth and success, and when the people of Canada come to rightly appreciate its importance they too will insist upon the industry being established in the Dominion. The timber in this country is being rapidly cut down and all the various industries connected with it must in time gradually disappear; wooden ship-building, once such a large industry, is now almost a thing of the past; and what is more natural than that with the disappearance of our forests attention to our mineral wealth should increase, and steady, continuous employment be given to our people in mining iron ore, coal and limestone, making charcoal and coke, smelting the minerals into pig iron and working this up into the various shapes and articles? The vast amount of money required for plant and machinery, the army of men to whom employment would be given, the amounts of money paid in wages, the increase in both rail and water freight, and the increased inter-provincial trade which must ensue, make this subject of vital importance to the permanent welfare of the Dominion.

United States policy when subsidising railways.

How other countries have established iron industries.

English duties on bar iron.

Importance of the iron industry to succeed the lumber industry.

William Gerhauser—I am secretary and treasurer of the Union Iron company, established in this city in 1872. The subscribed capital is $200,000, all paid up. We are employed in the smelting of iron ores from charcoal and our output is 12,000 gross tons per annum. We smelt specular, hematite and magnetic ores in the proportion of 40, 40 and 20 per cent., the supplies of which are obtained from the Marquette district of lake Superior. It is delivered at our works by boat during the season of navigation, commencing the 1st of June and ending the 15th of November. The specular ore averages 66, the hematite 56 and the magnetic 62 per cent. The hematite when dried at 212° yields about 62 per cent., but we put it in the furnace in its natural state, with free moisture. The ores cost us this year eight cents a unit delivered at our mills. We make charcoal at five points in the state, the nearest of which is 80 miles and the farthest 185 miles from Detroit. They are all situated on lines of railway convenient for shipping. The coal is made in round kilns, two-thirds of the product being from hard wood, maple and beech, and one-third from elm, black ash and soft maple. The cost of wood ranges from $1.25 to $2.25 per cord, and averages $1.60 for hard and soft. It is bought from the farmers, who deliver it at the kilns corded up. One cord produces on an average 45 bushels, weighing 20 lb. per bushel; the hard wood will produce 50 bushels same weight, soft wood 42 bushels. It costs at the kilns about $5\frac{1}{4}$c. a bushel and $7\frac{1}{2}$c. delivered at our works. Our annual make is 1,000,000 bushels, the whole of which is consumed in our smelting works. From 85 to 90 bushels is required to smelt a ton of iron. We use a charge of 1,600 lb. of ore to about an average of 740 lb. of coal, and the time it takes to run through the stack depends on the capacity of the stack and the speed with which it is driven. The product of this charge is about 960 lb. The limestone for flux is got near the city and costs $1.25 per ton, but only three per cent. is required. Our iron is made expressly for car wheels and malleable iron. Its analysis shows for our best grade, silicon 0.980, phosphorus 0.186, and sulphur 0.017. This does not bring it within the Bessemer limit, which is one-tenth of one per cent. in the iron. We sell the bulk of our make in the United States, but we also export to Canada. In 1887 there were exported from Detroit 5,288 tons, all of which it is safe to say went to Canada. Our average selling price this year has been $19.52 cash per ton of 2,250 lb. f.o.b.; last year it was probably

Union Iron company, of Detroit.

Supplies of iron ore and charcoal.

Cost of charcoal.

Proportion of ore and coal in a charge.

Exports to Canada.

a dollar a ton higher. Canadian purchasers buy at the regular prices here and the Canadian duties are paid in addition.* I managed smelting works in Baltimore from 1870 to 1883, and there we used ores largely imported from Ireland. Spain, Elba and Africa. Some of the Irish ores were as high as 7 per cent. in titanic acid, but they were mixed in very small quantities with the cleaner ores. We have used Canadian ores which gave us good satisfaction, but the ores we now use answer our purpose as well and are cheaper by the rate of the duty. We employ about 30 men at the smelting works; two engineers at $2 a day, 2 keepers at $1.75, 2 helpers at $1.60, 2 stockweighers at $1.60, 2 top-men at $1.60, 4 coal men at $1.60, blacksmith at $1.50, carpenter at $1.50, and 14 yardmen at $1.45 a day. At the charcoal kilns the work is done by contract, about five men to a plant, and they are paid $1\frac{1}{4}$ cent per bushel loaded on the cars; we pay for wood, plant, horse-feed, etc. Our daily output of pig is 35 tons and we work the year round. This year we had expensive repairs to make and the furnace was out of blast about two months. This statement is for a normal condition of working, but things sometimes go wrong and repairs are expensive. For the last five years we lost about four months' time in making repairs.

Canadian ores.

Labor and wages.

Capacity of furnace.

George Hope—I am a member of the firm of Adam Hope & Co., hardware merchants, Hamilton, engaged in the importation of iron. We import both Scotch and English pig. The Scotch pig was laid down as low as $19.50 this year; that is equal to $14 and the duty added. We have laid down some good brands of Scotch at $13.50 which with the duty would be about $18—that is the long ton. English pig costs laid down here about 54s. 5d., equal to about $13.50. That would be equal to about $18 duty paid. In June the English and Scotch market was depressed. Last year the price would be about one or two dollars more; 54s. 6d. was the lowest we laid down No. 1 English, and 56s. 6d. the lowest for No. 1 Scotch. We do not import charcoal pig at all. There would be no fear of competition from England and Scotland for that class of iron. What is used comes from the Detroit furnaces, none from the New York furnaces. The price in Detroit would be about $21.50 the long ton. In Hamilton about 15,000 long tons of iron is used every year. Two or three establishments have gone into manufacturing water-pipe and they use a great deal of iron. No charcoal iron is imported from Great Britain that I am aware of. We import considerable English hematite. That is a superior quality of ore and is used for such purposes as strengthening castings for machinery and for making malleable castings. For making car wheels charcoal iron is used altogether, the supply of which comes from American furnaces and from the Three Rivers furnace in Quebec. There are four car wheel foundries in Canada, at St. Thomas, Montreal, Lachine and here. The Three Rivers iron is manufactured from bog ore. I do not know anything about the quantity they make; it is very limited, but they make a magnificent quality.

Cost of English and Scotch pig iron.

Charcoal iron.

Supplies of pig iron for castings.

Three Rivers iron.

William Copp—The firm of which I am a member (Copp Brothers) is engaged in the foundry business We have been in business at Hamilton since 1849, but not all the time in the foundry business. There is about $200,000 invested in our business now. We produce stoves, furnaces, grates, agricultural implements and steam engines. The value of our yearly output is about $160,000. We use the best brands of iron, the Coltness, Summerlea and some of the Londonderry. They cost us about $23 the long ton. We mix a quarter of the Londonderry, as we cannot use it by itself; it does not make clean work, being a slaggy iron. Perhaps it is a little stronger than the others, and I think it adds to the strength. We do not use charcoal iron at all, but I think we ought to as it makes the best malleable castings. I think it could be made in Canada. In Alabama they are producing charcoal iron at a very low price; I understand that from a gentleman who makes a great many car wheels. I think he said they were producing it at $13 a ton. I thought the question worth looking into and I cannot see why, with our iron deposits, our wood and intelligent labor, we should not be able to produce our own supply. I think a good deal of charcoal iron would work in for stove plates as well as for car wheels; I certainly think it would be a great advantage. We buy our iron; we do not import ourselves. We use from 700 to 1,000 tons of pig according to the season. There is a large quantity used at the pipe works. I suppose outside of the pipe works 5,000 tons a year is used in this city, and it might possibly go to 6,000 tons. I think they work the common brands of English

Classes of pig iron used in making castings.

Charcoal iron for malleable castings.

Consumption of pig iron in Hamilton.

* This makes the price to the Canadian importer plus the duty exactly $24, to which the cost of freight must be added.

at the pipe works, and some of the low grades of Scotch. It would be from $3.50 to $4 less in price than ours. I think if we used one-third charcoal we could use English and low grade Scotch iron and turn out a strong nice plate. Of course that would have to be experimented with. It seems to me strange that some person has not started the manufacture of charcoal iron in Ontario. My impression is that it would not cost more than half as much to start a charcoal furnace as it would to start an anthracite one, and the iron could be made in smaller quantities; I think it would be a safer investment. I do not see why we should not manufacture it as cheaply as they do in Alabama. The Three Rivers iron is very good and strong, but we never work any of it There was a furnace at Ottawa at one time, but it was an ill-advised enterprise. At that time they had to compete against the cheap Scotch and English iron, and we were buying the Scotch delivered here for $18; that was the best grade. We make a very much finer plate now than we did then, and we require the best iron we can get. At that time the duty was $1.50 a ton. I think it is an industry the government should stimulate in some way. I think the best way would be to give a grant of $50,000; it would be better than a bonus to some of those useless railways. The surroundings here are very similar to those of Sweden, and there they manufacture charcoal iron well and cheaply; it would be well to look into their system very carefully. If our machine men used more charcoal iron in their castings they would be of a better class and it would be better for the country. As soon as it is established that charcoal iron makes better work we will all be willing to pay more for it. We really produce better plate here than they do in New York, but the best is produced in the New England States.

Charcoal iron smelting a promising enterprise.

How the industry might be stimulated.

Use of charcoal iron in castings.

Adam Laidlaw—I am a member of the Laidlaw Manufacturing Co. of Hamilton; we manufacture stoves, furnaces and brick machines, and our capital is $30,000. I have been in the stove business seventeen years. We use a considerable quantity of pig iron, between 400 and 500 tons a year. We use a little of the Londonderry, but the greater part is Scotch. Two years ago we used a quarter of the Londonderry with the Scotch, but this year we have not used any at all. It is a good, strong iron, but it seems hard and I don't like it for stove plate. We only use No. 1 iron. The Londonderry pig is worth about $23 here. Summerlea is the principal brand that we use, and that is worth $23; it has not been higher than $23. I bought early in the season for $21 the long ton. We are using a little English iron this year; it is not as strong as the Scotch. I think the difference is due to the quality of the ore, but I do not know anything about the manufacture of pig iron. I think we could use charcoal iron mixed with the Scotch; it would strengthen and improve the castings. I have not gone into the matter and cannot say whether it could be manufactured here. There are eight foundries in the city and they will each use about 500 tons a year on the average. We employ about forty men. Machine moulders make about $2.25 a day and stove moulders by the piece from $2 to $3.50 a day. We shut down about Christmas and stop for about six weeks or two months; that has been done only these last four or five years.

The Londonderry iron not suitable for stove plates.

Charcoal iron would strengthen and improve castings.

Labor and wages.

H. A. Massey—I am a resident of Toronto and engaged in the business of manufacturing agricultural implements. For making gray iron we use about 2,000 tons of pig. For malleable iron we will have to use 800 or 1,000 tons of pig, and that must be charcoal iron. For our castings we use Scotch iron and some Canadian; we mix them. We sometimes use one-half Canadian, but do not care to use more than a quarter or a third. I use the term gray iron as referring to the iron as it is made into castings from the pig. We use from No. 1 to No. 4. I cannot tell the amount of pig iron that is used in Toronto, but I do not think much charcoal iron is used. I think that at Oshawa they use from 2,000 to 3,000 tons of charcoal iron for malleable castings. A large quantity of charcoal iron should be used in making car wheels. Scotch pig runs from $18 to $22 the long ton. It has not been less than $18 for some seasons. The highest price is in the fall of the year. In the winter it would of course cost more. The Londonderry costs from $19 to $21 according to number of brands. Charcoal iron is imported from Alabama, Cleveland and Detroit. At the works at Detroit it runs from $19 to $21 the gross ton. The duty is $4 the net ton. The freight from Detroit is $2 a ton. The Alabama costs something over $30, duty paid. The last quotation was $26 per long ton at the works. It is a better iron than the Michigan, being very like the Salisbury. The Salisbury costs about $36 a long ton delivered here. We have not bought any of that iron recently. In Alabama I think they use any kind of wood for charcoal, but hardwood is the best. If Canadian charcoal iron could be pro-

Mixed iron for castings.

Prices of Scotch and Londonderry pig iron.

American charcoal iron.

Charcoal pig iron for castings.

duced for a little more than Scotch or Londonderry, no doubt we could use it for nearly every kind of iron we want to make. It makes a stronger and better casting, and it would be simply a question of the cost. For machinery castings we want the best iron, and the expense is what has kept us from using charcoal iron. I would take charcoal iron at $24 a ton rather than imported iron at $22 ; I would consider it would be $4 a ton more valuable. Charcoal iron at $4 a ton more would command the market for all strong castings ; we could use 2,000 tons of it. I do not think the makers would go to the extra expense for pipe. They might do something more for charcoal iron in the stove trade. The manufacturers of agricultural implements would use it ; and if one used it and made better castings, competition would compel the others to do likewise. The cheapest charcoal iron at present imported costs $28 a ton, and if the Canadian were less than that it would command the market for charcoal iron. In order to encourage the manufacture of charcoal iron I am in favor of granting a bonus for a number of years. I would recommend a bonus of $2 a ton in addition to the present bonus and duty. But if it can be shown that they could make a profit of $6 a ton at present, then no further bonus should be granted. The cost of making it can easily be figured out by those who understand the business. I do not believe that in Michigan they make $6 a ton. I think they would be well satisfied to make $3 a ton. I think a great deal of iron is made at $10 a ton in Pennsylvania, and for less in Alabama. The question of making steel is more important than anything else in Canada. We have great difficulty in getting the steel required for agricultural purposes here. The works at New Glasgow turn out good steel, but they cannot make the quantity required in the country. It is important that something should be done to encourage the manufacture of steel. We import some from England, and some from Johnstown, Pennsylvania. They supply at Johnstown an article quite as cheap as in England, but it is of better quality. There are but two parties in the States that make the cold steel, and they charge about 25 per cent. more than the English, but it is far superior. It is made as true as if turned in a lathe, and wears better than if turned. We have been trying to get the government to take the duty off cold steel, or to get some one to manufacture it. I think the business in Canada would pay. It would take a very large establishment to supply the requirements of the country in that line of goods. If there is anything that should be encouraged it is the manufacture of steel. Charcoal iron is in the right direction, but steel is he most important.

Bonusing the industry.

Manufacture of steel.

Cheap fuel for roasting and smelting ores.

John Stewart—There are workable quantities of gold, copper and lead ores that might be utilised in smelting processes. The difficulty is to get cheap fuel, and we have that in this country. The heavy refuse from the saw mills could be made into charcoal for smelting purposes, while the sawdust from the mills could be converted into gas and used as natural gas is used, and we would have the best fuel for roasting our ores. We could smelt our gold, lead and copper ores, and use pyrites for making sulphuric acid to treat our phosphate instead of shipping it in the raw state. There are large quantities of pyrites between Ottawa and the county of Hastings, some of which hold a little arsenic and some do not. The phosphate country along the Kingston and Pembroke railway has not been developed to the extent that the Quebec region has, the trouble being that they have not had as good surface showings, but it is a very promising country. In Portland there is phosphate that occurs almost like rock ; it has a fracture and resembles square pieces of red syenite. I certainly think we have enough pyrites between the Ottawa river and Hastings county to treat all our phosphates and to export besides. I think that charcoal should be used for the blast furnace and gas for roasting and re-heating the iron. Gas has never been used for blast furnaces, though it possibly might be so used. The works should be constructed at a place where refuse could be obtained to make the charcoal and gas. It would therefore be necessary to erect works where there are large saw mills, as the amount of refuse required for gas would be very great. I have made a calculation of what it would cost to make charcoal iron in this country, and according to my estimate it would run less than $20 a ton. The selling price of pig iron now is about $20, and the bonus of $1.50 would give some of the profit. In answer to the question as to how I would meet competition, I would keep out British and American iron by raising the tariff. The present selling price of British iron is $20 here, but charcoal pig is worth $5 a ton more.

Manufacture of phosphates.

Charcoal iron.

E. B. Borron—Had the attempt to smelt copper ore on the spot at Bruce Mines proved successful an immense saving in transport would have been effected. Nor would it have been necessary to dress the ores to so high a percentage as when

sent to Swansea or Baltimore, and thus the loss of ore in dressing might have been lessened. Finally the refined copper, or at least part of it, would have found a home market. These important objects gained, it is probable that the mines would have yielded a reasonable profit for a number of years. The failure of the attempt to smelt the ore by the Welsh system was due, I believe, to the following causes :— At Swansea, where this method is adopted, the copper smelting companies are supplied with copper ores of many different varieties and degrees of richness, from all parts of the world. Experience has taught them that it is more advantageous to mix different kinds of ores in certain proportions and smelt them together than it is to do so separately. The mixed ore is more fusible, requires less fuel and produces a cleaner slag, that is, a slag which contains the least possible quantity of copper. When the smelting works were started at Bruce Mines there was practically but one kind of ore, commonly called the yellow ore or copper pyrites. This when dressed to yield 15 per cent. of copper was still mixed with so much of the rock or gangue of the vein that nearly one-half of the ore as brought to the furnaces was quartz or silica. It is said when treated by itself to have been a refractory ore, and as no other ores could be got to smelt along with it, and thus render it more fusible, the consumption of coal was very heavy. As this coal had to be brought from the mines in the United States, some 500 or 600 miles distant, the cost delivered at Bruce Mines was at least three times that paid by the Welsh smelters for coal at Swansea. Then the slags instead of being clean were found to contain three per cent. or more of copper. Finally the furnacemen or smelters, brought in the first instance from Wales or other distant points, could not be replaced during the winter season when navigation was closed, and only with difficulty and after considerable delay in the summer. Accordingly if any of them deserted, became insubordinate, were taken ill, or got drunk, the work was constantly liable to serious interruption and loss, if not actual stoppage. I was not at the mine myself while smelting operations were in progress, but those were some of the reasons given to me in explanation of the failure of this apparently feasible but unsuccessful and costly experiment. Fully alive to the importance of being able to smelt the ore on the spot I recommended the company to try the blast furnace, using charcoal, which might have been easily got for fuel. But they had suffered so severely from the unexpected failure of the Welsh process that the suggestion was coldly received and never renewed or acted upon. About 1869 or 1870 the West Canada company determined to put up the necessary furnaces and apparatus at the Wellington mines and to extract the copper from the ores by the salt process. I had myself studied this process some seven years before as carried on at St. Rollox in Glasgow, and entertained such a favorable opinion of it that I tried to raise a company to buy the Bruce mines with a view to its employment there. The experiment as conducted by the West Canada company however was not successful. I have never heard a satisfactory explanation of the cause of this failure. It was said that the high price of salt and the difficulty of procuring scrap iron, of both of which large quantities are needed in this process, contributed to its failure. The establishment of reduction or copper smelting works at some point between Sault Ste. Marie and Bruce Mines would, I think, greatly stimulate and encourage copper mining on the north shore. In the Welsh process of smelting I understand that about 1 to $1\frac{1}{2}$ tons of coal are required to smelt and refine the copper in each ton of ore. Thus it would appear much more advantageous under ordinary circumstances to take the ore to the coal than to bring the coal to the ore. But in this case the circumstances are exceptional ; owing to the enormous quantities of iron ore and grain passing downwards from lake Superior through the Sault canal to Cleveland and Buffalo most of the vessels are obliged to return light, consequently the freight on coal from Cleveland to Bruce Mines would now probably be less than one-half that of the copper ore going the other way. I am still strongly of opinion that some modification of the salt process will be found more successful in the treatment of our copper pyrites ore than any other, and in that process a comparatively small quantity of coal is needed. The process should be one adapted to the treatment of low grade ores containing say from 5 to 10 per cent. of copper, or lower than even 5 per cent. if the price were high enough to warrant it. Many veins produce ore which, if spalled and carefully picked over, may be brought up to 5 per cent. without dressing. If such ore simply spalled could be sold at some easily accessible smelting works possessed of crushing machinery, many men of limited means might be induced to engage in mining who would never think of doing so if it were necessary to erect expensive machinery to crush and dress the ore in order to render it marketable. If I am not mistaken

Failure of copper smelting operations at Bruce Mines.

Unfavorable conditions.

Extraction of ore by the salt process.

Copper-smelting on the north shore.

The salt process.

the late Sir William Logan, after a most careful and painstaking examination of the veins opened at the Bruce mines in 1848, estimated that there were some 3,000 fathoms in sight which would yield something like 25,000 tons of ore containing 6½ per cent. of copper as raised from the mine and without any dressing whatever. There are a large number of veins between Algoma Mills and the Sault Ste. Marie not so rich as those at the Bruce, Wellington or Huron Copper-bay, but nevertheless capable of producing a very great quantity of low grade ore such as I have mentioned. Many, perhaps the majority of those veins, will never be worked unless there be some copper reduction or smelting company in that section able to smelt or otherwise reduce the ores, and willing to contract for and buy them in the rough state I have described. It is greatly to be desired in the interests of copper mining, and of the district generally, that some enterprising company may be induced to take the matter up.

Economic sorting of ores for local smelting.

Frank Prout—We did not use stamp mills at the Wellington company's mines, all ours being crushing mills; they were put up in 1860. Operations were continued till 1875, but I am not in a position to give you the average output. We did our own smelting. We smelted all our precipitate from the reduction works and part of our sulphide. We shipped our copper to Swansea in south Wales. Operations were discontinued on account of depression in the copper market. We used coal for our smelting; it cost us about $5.25 a ton, I suppose about the same price as it is now. I do not think there is any intention of resuming operations again. While the market was good it paid good dividends. We based our calculations on 4½ per cent. copper; that is the average we ran through the crusher. The best was shipped to Swansea and contained 19½ per cent. The whole run of the mine was 4½ per cent. Copper to pay should be worth from 17 to 18 shillings the unit of 112 lb.; it went down to 7 shillings the unit. We had very little trouble with water, three hours pumping a day would keep the mine dry. We had no trouble in getting labor We employed from 140 to 200 skilled miners and about 140 surface laborers besides. Miners were paid $35 a month; they worked by contract. Surface laborers got $1 to $1.40 per day. Labor at the present time I think is about the same as then. Our chemical works were only in operation a couple of years, from 1871 to 1873. When copper commenced to fall, and we were about closing down, the chemical works were the most expensive and were closed first.

Works at the Wellington mines.

Richness of the ore.

Labor and wages.

Chemical works.

W. H. Plummer—When the Bruce mines were at their best they gave support to about 3,000 persons, one way and another. For the wet process at the Wellington mines I think a little over $100,000 was invested. I think the reason it did not suceed was that it was badly managed, and on account of the cost of material it could not pay to treat low grade ores. Besides, there was great waste. I think the reason the old system of smelting did not succeed was that they had not the proper men to look after it.

Smelting at the Wellington mines.

Dr. Edward Peters, jr.—I am manager of the works of the Canadian Copper Co. I was educated as a metallurgist at the university of Freiburg, graduated at twenty and came to Colorado, where after a time I obtained the position of government assayer. Since then I have had a large experience in my profession in different parts of the States and have been engaged to plan works in Portugal and Hungary. The company here has not yet attempted to treat the ores, but about 3,000 tons have been sent to be treated elsewhere. This combination of nickel and copper has not been met with before in such quantities as to require separation in a wholesale way. The only case of the kind in America is the Gap mine in Pennsylvania, and there they use the old European way of dissolving in acids, which would never do in our case. The process for the treatment of our copper ores which I approve of is the old German blast furnace method, greatly modified to suit American ideas and conditions. We first sort the ore, break it to the proper size and pile it upon wood in large heaps, setting fire to the wood. It burns for two or three months, sending off the sulphurous acid gas till about three-fourths of the sulphur is gone; then the ore that originally carried 35 per cent. or 40 per cent. should come out with 4 per cent. or 5 per cent The iron is changed into oxide of iron, and is virtually just like common iron ore; it has lost its sulphur and taken oxygen instead. The ore is then put into the blast furnace on the same principle as pig iron, and the sulphur combines with the metallic constituents which form the matte. The composition of the matte may be 30 per cent. sulphur, 20 per cent. nickel and 20 to 25 per cent. copper. If too much sulphur is kept in the roasted ore it takes up iron; our object therefore is to roast the ore as thoroughly as we can, there being always enough left to take up the nickel and the copper. Six tons

The Sudbury ores.

A peculiar combination.

A modification of the German blast method recommended.

Calcining the ore in heaps to eliminate sulphur.

of ore will produce one ton of matte. We are not yet in a position to say which of our mines is the most valuable, but as they now look I think the Evans promises to be better than any we have. It carries about the same amount of metal as the other mines, but there is more massive ore and apparently a larger body of it. I think the Evans will show, taking the average of the whole mass, $3\frac{1}{2}$ per cent. nickel, 3 per cent. copper, 40 per cent. iron, and 23 or 24 per cent. sulphur; that is about 70 per cent. metal and the rest rock. I consider the company justified in putting up large works and so advised them this spring. I generally only advise the erection of a furnace, etc., when I see enough ore mined to pay for expenses and the erection of the furnace; that is the case here. We shall have to get the matte refined elsewhere. The sending of a large quantity of matte into the States has never yet been tested, but Americans are so much more ready to alter their plant and undertake any new thing of the kind than Europeans that I think we shall be able to do better in the United States. I think we can dress a good deal of our ore to 20 per cent. Speaking in a wholesale way I think it will show about $2\frac{1}{2}$ per cent. nickel and 3 per cent. copper; that is, as it is mined. The Newfoundland ore is something similar to ours, but does not contain any nickel that I am aware of. Before I came here I understand some three shipments were made, one of which went to England and the others to the States. In shipping to England I do not understand that it was the intention of the company to be at all influenced by the result of the smelting there. The charges were so exorbitant on the other side that the company did not realise a dollar a ton on the shipment to Swansea. The ore contained 12 per cent. copper and \$35 to the ton of nickel. They allowed nothing for the nickel; the shipment was 1,000 tons and that was \$35,000 the company got nothing for. A large quantity of what was shipped was from the Cooper-cliff, and we figured up what they charged on the other side at the rate of \$50 a ton. Our eastern men charge only \$10 a ton. I consider the Swansea charges most exorbitant. The ores here are low grade, but I consider it pays better to work large bodies of low grade ores as we can figure exactly what we can do. The ore throughout the country is about the same as far as I have seen. Whether it would pay for copper alone would be a toss-up; if coke could be got at \$6 a ton, with good management a reasonable dividend might be paid. Mining would cost about \$2 a ton, breaking 30 cents, calcining 50 cents, and smelting into matte \$2.50; that is assuming a large quantity to be treated; a small quantity would be proportionately higher. A ton of matte containing 25 per cent. copper (500 lb.) would be worth from \$40 to \$45 in the United States market; that is taking into account the duty, but not the transport. If we were smelting for copper we would use ore with a higher percentage of copper. The present price of nickel is 65 cents a pound. I consider the price high and think if it were 25 cents or 30 cents it would be much more used. The total annual amount now used in the world does not exceed 1,000 tons, and that is principally used for plating. I think we will be able to sell it with a handsome profit at 25 cents or 30 cents. I think the company has sufficient stock of ore on hand to represent every cent they have spent here, and to build the smelting works. Of course that is only an opinion, but it is based on pretty good evidence. I have not yet had much to do with arsenical gold ores. I understand however there is not much dfficulty in getting rid of the arsenic; the arsenic being extracted leaves the ore very much as the ores here after roasting. The ore could then be smelted in a big furnace for about \$2 or \$2.50 a ton, and all the gold would be in the iron matte. That matte would be very saleable; almost the full value of the gold would be paid to get it for flux.

Composition of Evans mine ore.

Smeiltng works justified by the prospect.

Refining the matte.

Shipments of ore to Swansea.

An exorbitant charge for smelting.

Cost of mining and smelting.

Copper.

Nickel.

Treatment of arsenical gold ore.

H. P. McIntosh—Until recently we have had no experience in smelting our ores in Canada, but we have had large quantities smelted in New York, where it was successfully done. Within the last thirty days we have started a furnace at Sudbury, which is reducing the ore to matte very successfully. The process is successful in separating the copper from its associated minerals in the ore as far as we attempt to. The minerals contained in this ore are copper, iron, nickel and sulphur, the relative proportions of which vary very widely, and their economic value depends upon the percentages of the saleable product and the market value of the same. It would be impossible to fix an arbitrary value per ton upon these minerals in the ground. Our smelter consists of a 105-ton steel water-jacketed furnace, together with the necessary engines, pumps, blowers, etc. to run the same. Perhaps about one-half of the machinery was purchased in Canada and the remainder in the United States. Yet we will say that we give your country the preference in purchasing machinery there when we can get it. There are a great many things though in connection with the development of a mine that are not on

Smelting at Sudbury.

your side. The furnace was purchased from parties in this country (U.S.), but was made at Sherbrooke, Quebec. It is difficult to get miners and laborers at Sudbury on account of the isolated position of the mines. The men employed are largely Cornish and Welsh, and are paid monthly in cash. Following is the rate of wages

Labor and wages.

Mining captain	$145 00	per month.	Watchman	$1 75	per day.
Assistant captain	90 00	"	Engineer	2 00	"
Master mechanic	100 00	"	Machinist	2 25	"
Teamster	45 00	"	Pumpman	2 00	"
Drill runners	2 10	per day.	Fitter	2 00	"
Miners	1 75	"	Fireman	1 50	"
Laborers	1 60	"	Blacksmith	2 50	"
Foreman	2 00	"	Assistant blacksmith	1 75	"

SECTION VI.

MEASURES FOR AIDING AND ENCOURAGING MINERAL DEVELOPMENT.

It will always perhaps be a moot point how far the government or legislature of the province ought to go in aiding and encouraging a development of its mineral resources. The extreme view on one side would be that government ought to pursue a course of passivity, leaving the beneficent order of nature free in its operation; while the extreme view on the other side would be that government ought to nationalise the mines and operate them for the good of the people. Probably the true policy lies between the two extremes, but it is the opinion of the Commissioners that valuable service may be rendered by the government in at least four ways, viz.: (1) by procuring to be made a geological survey of the province, with particular reference to its economic minerals; (2) by establishing a museum of minerals and mineral products; (3) by collecting and publishing yearly statistics of the mining and metallurgical industries of the province; and (4) by making provision for the education of students to qualify them for engineering and metallurgical pursuits, and for the practical instruction of persons engaged in the mining industry.

Government service in promoting the development of mineral resources.

A PROVINCIAL BUREAU OF MINES.

A popular misunderstanding frequently exists as to the nature and utility of a geological survey, and it may be as well to explain that the purpose of such a survey is mainly to facilitate the development of its mineral resources. The best method of accomplishing this is not to set about an indiscriminate and unsystematic search for minerals, but to find out the extent, geological age, geographical distribution, mineral characters, etc., of the different rock-formations, and then by analogy on comparing these various formations with those of countries already geologically surveyed, and in the light of past experience in all parts of the world, we ascertain what minerals may be looked for among our own rocks. We also ascertain by this means which formations are probably destitute of useful minerals. While making such a survey the geologist will of course keep a sharp look-out for all indications of valuable minerals, and will examine carefully the geological relations of such as may be discovered by others. Should some formation prove rich in a certain useful mineral, if we have traced out its boundaries or its geographical distribution, we know at once the limits of the most promising ground to explore. If we know further the particular conditions under which such mineral occurs within this formation, our field of search is greatly narrowed and the chances of success are correspondingly increased.

Method of accomplishing the object.

Methods of operating.

Geological surveys in the United States.

In most of the states of the American Union geological surveys of a more or less efficient character have been made, and for many years similar surveys were carried on under different heads in the western territories. It was found however that these numerous independent surveys were giving rise to great confusion in geological nomenclature and map-making, and it was becoming more and more difficult, especially for outsiders, to correlate the rocks of the several states and territories. Under these circumstances the central government a few years ago very wisely undertook a general geological survey of the whole country, leaving the individual states free, if so disposed, to carry on their own surveys as before. In Canada we had begun this work in the reverse and more systematic order, by making the general survey first. The geological survey of old Canada was commenced by the late Sir William Logan in 1843, and at the time of Confederation it was extended under the same able director to the whole Dominion. As a result we have now a sufficient general knowledge of the geological features of the country from the Atlantic to the Pacific, and a uniform system of classification and nomenclature of the rocks has been established. But the time seems to have come when each province should undertake a more detailed and utilitarian survey of its own. In the province of Ontario at all events our mineral wealth has been proved to be of such importance as to abundantly warrant this undertaking, with every prospect of its proving a highly profitable investment for the country.

Surveying operations in Canada.

When the geological survey of old Canada was begun the main object which the public and the legislature had in view was clearly the investigation and development of the mineral wealth of the country, but latterly this primary aim has been subordinated to other objects. Under the old regime a fair general knowledge of the geology of the greater part of Upper Canada had been arrived at. Since Confederation however a much smaller proportion of the work of the general geological survey of the Dominion has been devoted to Ontario, notwithstanding the fact that the sum now annually appropriated for this service is more than five times greater than was the average yearly grant before Confederation, and of which this province must contribute at least one-half. Thus it happens that at present there are numerous districts of great economic importance in which little or no detailed work has been done, and in regard to which very little systematic information is available.

Original object of the Canadian survey.

Ontario's share of the service.

It is a curious anomaly that while the mineral lands belong to the province, and the existing geological survey is largely paid for by its people, yet its government has no control over the institution supposed to exist to a great extent to promote their development. If therefore the geological survey carried on at the public expense is to be utilised for the development of the mineral resources of Ontario, it appears likely that it must be under the control of its own government. The officers of such a survey could be directed to thoroughly examine and report on any district where valuable minerals might be discovered or where they are already known to occur. In this way an immediate and practical local service could be obtained by the government whenever required in the public interest without interfering with

Importance of provincial control.

the general plan on which its operations might be carried on. This might often prove of great importance in promoting the speedy development of new and promising districts, increasing revenue and carrying out the government policy, whereas at present no such assistance is available. The crown lands and crown timber of the province are important sources of revenue, and the government has a staff of officers conducting the business of the department. The mineral resources of the province if not already equally important as a means of income might be made so, and at any rate they are of great moment to the community, and therefore might with equal advantage be placed in charge of separate officers connected with a bureau of mines. Crown lands and timber.

The ordinary work of the provincial bureau or geological survey might consist in the systematic investigation and mapping of one district at a time, with special reference to its economic minerals. Besides mapping out the geology of the metalliferous districts the officers of such a bureau would enquire into and fully report upon such subjects as our petroleum and natural gas fields, salt and gypsum deposits, building and ornamental stones, brick, tile and terra-cotta clays, limes and cements, peat and lignite, shell marl and phosphates, flagstones and slates, grinding and polishing materials, moulding sands and materials for glass-making, etc. A study of the superficial deposits would also be of importance not only in relation to agriculture, but in regard to questions affecting wells and water supply. Information is often required in connection with obtaining supplies of water by boring into the solid rock, and valuable advice in this line might be obtained through the proposed bureau. Proposed work.

A practical bureau of mines of this character might be the means of furnishing the provincial government with much valuable information on other than strictly geological matters, such for example as whether a new district, which it might be proposed to lay out into townships, was too rocky for agricultural purposes or whether the soil might be only fit for the support of timber and the district incapable of being converted into a successful agricultural settlement. Reports could be made on the soil as well as the rocks of each particular area examined in new districts. Incidentally information could also be furnished without additional cost on such subjects as timber, fisheries, etc. Other information.

It should not be forgotten that it is often almost as important for the government and the public to know what districts or formations are destitute of valuable minerals as those which contain them. This can only be ascertained by intelligent investigation, and such knowledge often prevents disappointment and the waste of large sums of money. It has been estimated that in Great Britain the money saved from the indiscriminate and fruitless search for coal alone where there could be no hope of finding it, such as had formerly gone on, has been more than sufficient to pay the whole cost of the exhaustive geological survey of the kingdom. Districts destitute of minerals. Money saved.

For the above reasons and others about to be stated the Commissioners would recommend the establishment of an economic bureau of mines for the province in connection with the department of crown lands or that of agriculture, to be under the management of an officer who might be called the director of such bureau or the chief inspector of mines. In some of the other pro- An economic bureau of mines.

vinces of the Dominion, as well as in India and in various British colonies, inspectors of mines have been employed for years as indispensable officers of the respective governments. Considering the extent, population and wealth of Ontario, and the importance of her vast mineral resources, the appointment of such an officer and the independent investigation of these resources appear to be urgently called for at the present stage of our history.

Contributions to geological science.

While the first and main object of the bureau of mines for Ontario here recommended would be to ascertain and make widely known the mineral wealth of the province, the keeping of this object constantly in view need not impair its usefulness also as a scientific institution, contributing its share to the sum of geological knowledge which every civilised community should aim to advance.

Means of increasing the wealth of the country.

The rapid development of our mineral resources is the best means which remains for increasing the wealth of the people of this province. By promoting this we will attract capital from without, encourage the manufacture of machinery in the province, thereby increasing the consumption of iron and steel, give employment to a larger population, which would in its turn consume our manufactured goods, agricultural produce and lumber. An increased mining industry would in fact become the completement of the agricultural, manufacturing and lumbering industries. The railways and the shipping, too, would be specially benefited. In the United States and various European countries the carrying of minerals is depended upon by the railways as one of their chief means of support, and it is said that without this branch of their business few of the leading railways in Britain or the northern states would pay at all. The most legitimate means by which people can really enrich themselves is to extract wealth from mother earth direct, and the mineral resources of Ontario are no doubt destined to become one day our chief reliance for this purpose. Some of the others, such as the timber and the fisheries, must in the very nature of things decrease, while in this we have a means of constant increase and apparently unlimited possibilities.

Importance to railways.

Qualifications of a geological officer.

The geologist or inspector of mines should be well versed in the geology of the province, and should have a sufficient knowledge of mines and mineral deposits in general to enable him to give useful advice when desired to those actually engaged in mining, or to persons proposing to work undeveloped properties. From his responsible office and neutral position such advice would naturally carry more weight than that of experts employed as special pleaders, no matter how well qualified they might be.

Practical service which he might render.

Persons unfamiliar with minerals are often dazzled by bright appearances or fancied resemblances to rich ores they have seen elsewhere, and are thus tempted to spend money on worthless property, or at any rate in having expensive analyses made, which could be easily saved by applying to a responsible person who had nothing to gain by encouraging their erroneous notions and who was to be depended upon to tell them the truth. The greatest curse of mining in Ontario has been the custom of persons who owned lands or who had taken up 'mining locations' and (because they happened to own them) endeavoring by every kind of means to create the belief that they were mines, irrespective of the fact that they were not intended for such by nature. The

efforts of these promoters would be much better directed if they were to spend a corresponding amount of labor in endeavoring to find a real mine, for which our practically unlimited mineral lands afford them excellent opportunity.

Equipment of the office.

The chief of the bureau should be able to explain to applicants the uses and values of any economic minerals which they may have discovered, and also where to find a market for them. His offices should be well provided with general and local geological maps, sections, diagrams, etc., as well as plans and sections of all existing mines; and he should take care to procure and preserve drawings of all new workings for future reference, in case they may be required in the subsequent working or re-opening of the mines they refer to. A want has been felt for such documents in all old mining countries, and already in several cases even in this province. Mineral statistics of all kinds should also be collected every year, and correct tables and explanations with regard to them should be published annually. A vast amount of mining information well worth putting on record is now available from various sources.

A bureau of information.

The headquarters of the provincial geological survey would thus become an important bureau of information on all points in relation to the mines and minerals, and indeed of all the material resources of Ontario. Should any question arise on which the government might require information concerning the minerals of the country it would here have at hand an immediate means of reference such as is not now available. A want is also felt at the present time for a central means, such as this would be, for the distribution of reliable or official information in the United States and Europe regarding the great mineral riches of the province. In addition to frequent reports, the director might give the public the benefit of his knowledge and experience through the medium of lectures delivered occasionally in the principal centres of population or in the mining districts in a manner similar to that which has been adopted by professors of the agricultural college under the scheme of farmers institutes.

The value of a geological survey to the province is very ably stated in the evidence of Mr. Walker, general manager of the Canadian Bank of Commerce, appended to this Section.

A PROVINCIAL MUSEUM.

Value of knowledge of our] mineral resources.

One chief reason why the development of our mineral wealth has not been more rapid heretofore is, that only the most empirical kind of knowledge was possessed by most of the pioneer explorers. Of course nothing else was to be expected. Neither European nor Canadian settlers of the agricultural class were likely to possess even the rudiments of such technical acquirements in mineralogy as might enable them to distinguish ores, far less the knowledge that would enable them to determine the existence of minerals in paying or non-paying quantities as indicated by the character of the deposit and the accompanying geological conditions. There are few pursuits more fascinating than that of the search for minerals, especially the precious metals, and too often it has proved illusory, and worse, when carried on by persons of the kind referred to, who, having picked up a little knowledge relative to the appearance of this or that ore, become infatuated with a desire to attain wealth

at a stroke, and thus bring themselves and their families to poverty and render life miserable in search of the impossible. On the other hand it has frequently been the case that comparative riches have lain within the grasp of a man who was totally unable to perceive the value of what he daily trod over. It is therefore advisable that steps should be taken to educate the masses in some degree, and to attract the attention of outsiders,—foreign capitalists, prospectors, scientists, miners and manufacturers—to the mineral resources of Ontario, and to have a representative collection of them available for reference at the most central place possible.

A representative collection for reference.

The great exhibition of 1851 first taught how much good might result from national as well as from local and individual displays. Similar international fairs in both Europe and America have but added force to the original lesson, and the very last in the series, that held at Cincinnati during the last summer, has been the means of attracting marked attention to our province and its mineral wealth. So direct and so far-reaching were the results arising from the Hyde Park exhibition in London that a permanent establishment of a popularly technical character has ever since been maintained at Kensington. In every European capital and in hundreds of other European large cities, as well as in Washington, Philadelphia, New York, Boston and other places in the United States, there are excellent museums of an instructive kind. In every state capital of the United States there is a collection illustrative of the local mineral resources in connection with the various state geological surveys. At Ottawa it is true Canada is pretty thoroughly represented geologically and mineralogically, but this province is of sufficient importance to have individual representation in its own capital for the benefit of its own people, as well as for that of the hundreds of thousands who annually visit us from all parts of Europe and America. The facilities for the formation of a museum in Toronto are unsurpassed in any country. Already more than a nucleus exists in what is in possession of the government as exhibited at Cincinnati, besides the specimens collected by the Mining Commission. Indeed all this material has been left with the government by the individual exhibitors for the purpose of being placed in a permanent mineralogical museum, as was intimated to them by circular to be the intention. But besides specimens of ores and minerals and the rocks in which these occur, the museum should also contain a full collection of products illustrative of the various stages in metallurgical processes. This is an essential feature of a museum whose purpose is to inform and educate, and to students of mineralogy it would possess great value.

Lessons of the exhibition of 1851.

A museum at our provincial capital.

A means of practical instruction.

Intimately associated as the educational system of the province is with our governmental machinery, it would be an easy matter to supply from the superabundance of material to all the leading schools and local museums typical specimens of rocks and ores. Already there is a sufficient quantity of copper, zinc, iron, barytes, gypsum and other minerals for this purpose. Every mechanics' institute might be supplied and specimens could even be furnished to important private or denominational seminaries, on condition (as is demanded by the Geological Survey authorities at Ottawa) that they should in no sense be regarded as individual property and that they be placed on

Local museums.

exhibition in suitable cases. In a few years it would be found by this means that the popular knowledge of our minerals would have greatly increased and an incentive to study would be offered to those whose tastes might run in that direction, the capabilities of the country would become more widely known, the capitalist, prospector and scientist would be especially assisted, and material benefit would be the natural result.

A means of practical instruction.

There seems to be no reason why the formation of such a collection should be delayed. Awaiting the preparation of room to contain the exhibit permanently, the work of getting together, assorting, classifying and labelling could now be going on, so that without loss of time the products of our mines, quarries and deposits of all kinds may be on exhibition. We want the world to see our granites, marbles and serpentines, both polished and in the rough, our fine sandstone, freestone and limestone, our gypsum and phosphate, our iron, copper, gold and silver ores, with our petroleum, salt and marl, and all other minerals and mineral products of the country. Topographical and geological maps and sectional drawings might also be hung in the museum or kept for reference.

MINING STATISTICS.

In the first report of the United States geological survey, made to the secretary of the interior by director Clarence King in 1880, the utility of mining statistics is briefly but cogently discussed. The resources of that country are vast and great progress has been made in their development, but at the time Mr. King wrote nothing was definitely known of the mining industry excepting such information as had been gathered and published once every ten years by the officers of the census. Private citizens could only hope with great difficulty to procure the data of a single product, and even where private associations were formed for the purpose, such as the Iron and Steel Association, their work was fragmentary and imperfect, and it was made to serve their own rather than any public ends. Looking at the subject in this view, Mr. King made the following observations on the importance of mining statistics:

Utility of mining statistics.

> As a direct result of the size of the country, the government and people have long been uninformed as to our primary industries ; those, I mean, which yield the raw materials—mineral, vegetable and animal.
>
> To the agricultural department we owe the first reforms from this condition of wide-spread ignorance. In the realm of mineral productions the only efforts made to acquire any positive knowledge have been the highly useful but feebly endowed works of the late mining commissions, whose investigations were suffered to end for lack of appropriations.
>
> Today no one knows, with the slightest approach to accuracy, the status of the mineral industry, either technically, as regards the progress and development making in methods, or statistically, as regards the sources, amounts and valuations of the various productions.
>
> Statesmen and economists, in whose hands rest the subjects of tariff and taxation, have no better sources of information than the guesses of newspapers, and the scarcely less responsible estimates of officials who possess no adequate means of arriving at truth.
>
> In no other intelligent nation is this so ; on the contrary, mineral production is studied with the most elaborate effort. England, France, Germany, Austria, Russia and Italy consider it essential to know from year to year not only the source and aggregates of amount and value of mineral yield, but many lesser facts relating to the modes and economies of the industries.

Upon considering the extent of country over which our minerals occur, their wonderful variety and yet unmeasured amounts, it cannot fail to be apparent that no private individual or power is competent to do what ought long since to have been done, namely, to sustain a thoroughly practical investigation and exposition of the mineral industry.*

Collection of statistics in the United States.

The first report of real value on the mineral productions of the United States was made by Mr. King himself in the geological survey report of 1880-81, being preliminary to the full and exhaustive report on precious metals which forms volume XIII of the census of 1880. In 1882 a division of mining statistics and technology was established in connection with the survey, with a large corps of men engaged in statistical work, and since then a report has been published yearly on the mineral resources of the country. It contains a mass of statistical and other information, but in accordance with the plan adopted by the director only the more important lines of enquiry are pursued. It lacks the completeness of a census, but is nevertheless a useful record of the progress of mining operations and metallurgical processes. In a number of states bureaus have been organised for the same object, as in Michigan, Ohio, Illinois and Pennsylvania; and their reports are doubtless freely drawn upon in the preparation of the geological survey volume.

Mineral statistics in Canada.

Until very recently little attention has been given to reports upon the mineral production of Canada, excepting in Nova Scotia and British Columbia, and in those provinces the collection of royalties makes the work to a large extent an incident of the public revenue. In Ontario, although mining operations have been carried on to some extent for half a century, no records have been preserved saving in a desultory way and at long intervals of time. Indeed the only records we possess for the whole province are those of the Dominion census, taken for the first time in 1871 and again in 1881; but even the returns of the census are very meagre, since the only information they give is the quantity of raw minerals produced in the preceding year. There are in these none of the ordinary statistics of capital invested, the number of men employed, the wages paid, the value of the ore, the quantity smelted or treated at home or shipped to foreign countries, or any fact concerning the origin and progress of mining enterprise in the country. Yet there is much interesting information on these subjects available—scattered through reports of the geological survey and of the crown lands department, in special reports and contemporary newspaper records, or procurable from men still living who were pioneers in the industry—and no scheme of statistics would be complete which did not take account of all those sources for materials out of which to write the story of the beginnings and growth of the industry.

Statistical work of the geological survey.

The geological survey at Ottawa made an attempt to collect and publish annual statistics in 1870, but the returns made by miners were so few and imperfect that the work was discontinued at the end of the third year. It was resumed however in 1886 and three annual reports have been published. These are an improvement on the earlier reports, but excepting for the provinces of Nova Scotia and British Columbia they are far from complete. A

* First annual report of the United States Geological Survey, p. 76.

system of co-operation between the provinces and the geological survey might possibly lead to more satisfactory results, more especially as the older provinces have the management and sale of the public lands and the exclusive authority to make laws relating to real property.

But were an arrangement of this kind entered into it should aim to provide for something more than bald figures of the quantity and value of products. Capital is essentially timid, and successful mining must be conducted on legitimate business principles. Hence a report on the industry should give all information which an investor requires. The cost of labor, provisions, timber, explosives, fuel and all other factors of cost, including buildings, plant and development work; sources whence the various supplies are drawn; position of mines relatively to the lines of communication; rates of freight; points to which products are distributed; comparisons of systems of working, or processes employed in various districts; social and vital statistics of mining communities,—these and other topics of enquiry of a similar character cannot be passed over in any scheme which seeks to encourage the industry by the supply of practical information. A knowledge of processes in mining, milling, smelting, etc., and particulars of construction, adjustment and management form a necessary part of every successful miner's occupation, and are valuable alike to the workingman and the capitalist. And if to making enquiries on those lines there be added the duty of collecting average specimens of all known mines and mineral locations, and procuring assays and analyses of them, a most important service may be rendered by the government of the country to all who are engaged in mining and its allied industries. There is hardly room to doubt that apart from its economic value an annual report showing the condition of mining and metallurgical works in this province would effect valuable results in directing attention to the extent and variety of its mineral resources.

Scope of statistical inquiry.

Specimens, assays and analyses.

Owing to the small number of mines in operation in Ontario the Commissioners did not make the collection of statistics a subject of particular enquiry, but in every instance in which the views of witnesses were obtained the utility of statistics was freely acknowledged.

TECHNICAL INSTRUCTION.

The witnesses examined by the Commission are almost unanimous in the opinion that there is great need of technical instruction in all operations relating to the mining and metallurgical industries of the province. Few of the men who prospect for minerals have the practical knowledge which would enable them to explore the country intelligently or successfully. Time and means are often wasted in searching for the precious and economic minerals through districts where there are none, and where nature never designed that any should be. Some knowledge of the geology of the country, and of rocks and minerals and their relation to each other, is of obvious advantage to the prospector; and if he is also able to use the blowpipe, or make the ordinary tests for metals, his quest cannot fail to be infinitely more satisfactory than it could be without such knowledge, and he may be saved from much disappointment and loss. Many of the prospectors met with by the Commissioners in the northern districts were qualified to do little more than make a collection

Need of technical instruction in the mining and metallurgical industries.

Prospectors.

of rocks and what seemed to them to be minerals, and forward them to Toronto or elsewhere for assay or analysis. Some were unable even to make the common and simple test of minerals under the knife; and it is doubtful if one man in ten could make a map or sketch of the district he had examined, so necessary for good prospecting work. Men of this class are possessed of little means as a rule, and when after much hardship they have been fortunate enough to make a promising discovery they have only in rare instances the means to prove its value as a workable vein or deposit. Skill and experience are required in sinking test pits and shafts and opening trenches to show the extent of the ore body, and without judicious exploration to determine whether the quantity and richness of the ore are sufficient to warrant the development of the property as a mine, capital can rarely be tempted to touch it. And as it is with the prospector, so it is also in a large degree with the explorer and miner in our country. To dig a well is one thing, but to sink a shaft or drive a tunnel and strike or follow a vein of ore is another and wholly different thing. The one work any unskilled laborer may do successfully; the other calls for skill even in the laborer, and direction under a mine superintendent of large experience if not of scientific training. Mining operations in Ontario have oftener resulted in failure than in success, even where they have been directed by men of good reputation; but the method of mining employed depends very much on the character of the formation in which the ore or vein occurs, and the miner who has learned his business elsewhere may find when he begins upon a deposit in our Archæan rocks that he has practically to learn it over again. This has been the case in the Hastings and Sudbury regions, in working iron, gold and the nickel and copper ores, as well as in working the silver mines of the lake Superior country. Greater knowledge is required to work a mine than to prospect for minerals, and, as some one has said, the serious problem is to increase the number of men in whose training theory and practice have been so combined that they can meet the great demand for those who can put theory and practice together. And from what has been said in the preceding Section it must be apparent that in the methods of extracting metals from their ores there is a necessity for skill of a higher order than is called for in raising the minerals out of the earth. In prospecting, in exploring, in mining, in reducing, in smelting, in refining, men must have knowledge of how the particular work is to be done before they can hope to do successful work; and whether their information is gained in the schools or by the hard experience of practical life, the mind guides the hand.

iners.

Metallurgists.

The numerous excerpts in the Appendix, taken from the report of the Royal Commission on Technical Instruction, the presidential addresses of Professors Richards and Egleston before the American Institute of Mining Engineers, the New Zealand Handbook and other sources, deal with the subject so fully that only a few general observations need be made here.

Appendix excerpts.

Schools of technical instruction are usually designed to give a thorough course in one or more lines of special study, extending over a series of years. Thus in the Columbia School of Mines there are seven courses, each of four years, viz: Mining engineering, civil engineering, metallurgy, geology and

Schools of technical instruction.

palæontology, analytical and applied chemistry, architecture and sanitary engineering, and no student is allowed to pursue more than one course at a time. Now a graduate of the metallurgical or of the mining engineering course would probably lack nothing which a prospector or miner ought to know, but either one would be much too thorough and expensive for his needs. A much more practical course of instruction would be such as is provided by the government of New Zealand, where a university professor and a staff of qualified assistants establish schools in the vicinity of the mines and give a series of practical and elementary lectures on such topics as will be of most advantage to men in their daily work. The scheme of these schools is fully stated in the Appendix. Another scheme has been suggested by two or three witnesses examined by the Commission, viz: that in some of the mining districts, as at Madoc and Port Arthur, the services of a science master at the high school might be utilised to give instruction to miners and prospectors as part of the regular course, or by the establishing of evening classes, and that a special grant in aid of such a scheme might be made by the government.

Schools for miners.

The thorough course which a technical or scientific school provides, and which is intended to qualify men to fill the highest positions in the business to which they purpose devoting their lives, may combine theory and practice within its own course, as is the case with most of the American schools, or it may combine theory in the class-rooms and observation of practical work outside, as is the case with some of the European schools.* The American system of mining laboratories is thus described by Prof. Richards of the Massachusetts Institute of Technology as practised at that well known school :†

Parallel courses of theory and practice.

A student is assigned a quantity of ore weighing five hundred pounds to four thousand pounds, according to kind. He assays it and makes mineralogical and chemical tests of it. He consults the books to see what processes are available for such an ore. He discusses the different processes before deciding. He chooses one and works the ore through by it, testing by chemical analysis not only for the metals of commercial value to see what becomes of them and to ascertain where the losses are hopeless and where they can be diminished, but also to see what quality of products he has obtained, whether the slags are those of the standard of

The American system of mining laboratories.

* "There is what may be called the system of Freiberg, as it is so well represented at the great school in Saxony, where the men study metallurgy theoretically in lectures to which a somewhat limited laboratory course is added, the great feature of the instruction being the facilities which the men have for spending a portion of each day in the Halsbruckner Hutte or the Muldner Hutte, these being the great works of the district in which the school is situated; and, finally, there is the system adopted in America, especially at the School of Mines, Columbia College, New York, and at the Massachusetts Institute of Technology at Boston, where, in addition to laboratory work as ordinarily understood, students carry out metallurgical operations, more or less experimentally it is true, but, as an engineer would say, on a scale of nearly 'twelve inches to a foot.' Surely, it may be urged, the frequent opportunities for seeing metallurgical operations must be of great benefit to the student; but consider how short a time a student who is preparing for the higher branches of his profession can possibly give to the purely theoretical work which he must get through. Such a student has no leisure, in addition to that which should be set aside for exercise; and if he had leisure I do not think he would be putting it to the best advantage if he were to devote it to looking on at a metallurgical operation conducted by someone else; and I believe that no system by which a student accompanies a demonstrator or even a local foreman to works, and only sees the successes and not the failures of other people's labors, really affords him adequate instruction. . . . It will, I trust, have been understood that I have been speaking only of the training of a student; his career as a metallurgist can only be perfected in the works, because the manager has not only to deal with metals but with men."—Prof. W. C. R. Austen of the Royal School of Mines, London, quoted by Prof. Richards.

†Transactions of the American Institute of Mining Engineers, vol. xv, p. 317.

silicification he aimed at, whether the mattes, bullion, etc., are of the quality he planned for. He is assisted by his classmates in his work, and he in turn assists all of them in theirs. This work is interspersed with the studying of collateral literature and reading of papers before his class upon the subject to which he is devoting his time. A year of such training, following after three years of preliminary technical school work, does not to be sure make an engineer of him, but it gives him a valuable lesson, most of it self-taught, in each of the following directions:

1. In accurate habits of thinking and working.
2. In acquisition of independent judgment.
3. In the habit of applying knowledge, which habit stimulates acquisition.
4. In gaining real experience by the sweat of emergency.
5. In managing men and controlling himself.
6. In appreciating the value of labor and the workman's view of things.
7. In taking the conceit out of him.
8. In the use of chemistry to control metallurgy, and in the use of technical literature for suggestion and warning.
9. In keeping accurate accounts and records of his work.
10. In solving problems that are new to him.

Prof. Richards does not claim that his school is better than any other. but he does claim that he can teach metallurgy many times better with a laboratory than without one; and with the appliances of the modern school, which enable practical instruction to be given in stamping, amalgamating, smelting and refining on a large scale, he says very properly that the work savors as much of mining as of metallurgy. In most of these opinions Prof. Egleston, the mineralogist and metallurgist of the Columbia School of Mines, agrees with Prof. Richards. In his address as president of the Institute of Mining Engineers in 1888 he said:

The students' interest in laboratory work.

No one thing is more striking than the interest which students take in all kinds of laboratory work, whether it be chemical, physical or mechanical, and the evident relief and recreation which it brings to them as a change from purely mental labor to that which occupies the eye and the hand. For the time being they become investigators, acquiring knowledge, making researches, drawing conclusions, watching reactions and noting the working of different principles. Their work to them has just as much importance as if they were original investigators instead of learning how to investigate. Laboratory work—in which the closest attention must be paid to get the results, and the greatest accuracy is required to interpret them after they are obtained—not only gives to the student a capability for observation but a power of concentration of mind not easily obtainable in any other way, because the men are interested in obtaining results which they are themselves to interpret. . . . The old idea was that any time devoted to labortaory work more than a certain minimum was wasted. The results of modern experience show that theory can be better taught in the laboratory than in the class-room, because its application follows at once on its announcement. It is thus fixed in the memory and ceases to be an abstraction. Besides, if the habit of applying knowledge is not learned in the schools it will hardly be learned outside of them except by a long and painful experience. Both as mental recreation and to train the powers of observation necessary for practical life a certain number of hours each day should be devoted to laboratory practice of some kind, so that the application of the theory may be learned at the same time as the theory itself. . . . In all laboratory work the principle should be to teach men how to do good work, but not to waste time after they have learned how. It is not the object of the professional school to make skilled workmen of the students. The moment they have learned how a piece of work ought to be done they are capable of teaching those who occupy an inferior position how to execute it properly, and if this instruction has been coupled with the teaching of how to accomplish what is to be learned with the least amount of time and expense of material, they can teach other men to be skilful without necessarily being skilful themselves. . . . . What is wanted of the engineer is not to do work accurately with his own hands, but to know how to do good work and to recognise it when it is well done and how to correct what has been poorly executed.*

Modern experience of laboratory work.

The principle to be kept in view.

*Transactions of the American Institute of Mining Engineers, vol. xvi, pp. 643-6.

Here in Ontario there are few mining engineers or metallurgists, chiefly no doubt because we have hitherto had so little need of their service, but also because we have no schools or colleges where they might receive instruction. Should the mining industry become established a demand would necessarily arise for men of technical training, and in that event our schools ought to furnish them. Our young men have now to go abroad for special courses, and it is not unlikely that a majority of their number succeed in getting foreign employment and never return. It is hardly creditable to our province, with its excellent schools for primary and higher education, that no suitable provision is made for a thorough course of instruction in mining engineering and metallurgy, especially as the country is believed to be rich in minerals, and that most of the ventures hitherto made to raise and treat the ores have resulted in failure through want of skilled knowledge to carry on the operations. The School of Practical Science provides a part course in both subjects, by the instruction given in civil engineering, chemistry, mineralogy and geology, and the most obvious plan would seem to be to strengthen that school by the addition of one or two professors of good standing and furnish it with a first-class mineralogical museum and appliances for the extraction of metals from their ores. It may be said that a school of this kind ought to be located at some point convenient to the working mines, where practical operations could be witnessed, as is the case in Michigan and also in several European countries. But the Houghton school has its reputation yet to make, and in view of the eminent success of such institutions as the Columbia School of Mines, the Massachusetts Institute of Technology, the Royal School of Mines, London, and the Ecole des Mines, Paris, it would be rash to say that a similar school in Ontario could not prosper in its chief city and attached to the provincial University. It would be at least an experiment to establish a new school far out from the centre of population, where a complete and independent staff of professors and instructors would require to be maintained, instead of utilising an institution already established and well equipped to give instruction in the scientific part of the course; and a good course in the sciences must always be an essential part of the training in technical schools.* It was the opinion of Sir Lowthian Bell, as stated to the Royal Commissioners on Technical Instruction, that, as in France and Belgium, a much better purpose would be served by establishing technical schools throughout the country and that every industrial district had a pre-

Importance of a school for technical training in Ontario.

The School of Practical Science.

Local technical schools.

*In his evidence before the Royal Commission on Technical Instruction Dr. C. William Siemens said: "If I were to draw a comparison between a man who has been taught science to the highest point and then thrown into practical life, with no contact with the development of science, and another who has not had those advantages but who has had opportunities of refreshing his knowledge and advancing with the rapid advance in science and applied science, the balance would be entirely in favor of the latter. There is no such thing as a resting place in science, and still less in applied science. The processes of to-day are no longer the processes of to-morrow; that is where a man of polytechnic training is often at a disadvantage as compared with others; his education in science and applied science has become to him a treasure which he likes to dwell upon, and by new discoveries all this treasure falls to the ground, and he has to wander about like anybody else, trying to understand this new advance. It is for that reason that I am very strongly of opinion that applied science may be very easily overtaught, but that the fundamental principles of science can never be overtaught because a person who is well impressed with those fundamental principles will hail with delight a new advance, because he sees how one principle has led up to another, whereas a person who has been taught science in its application is offended with the new advance and is at a loss how to deal with it.—Report, vol. III, p. 135.

ferential claim to London. " But still do you think it would be better," Mr. Magnus asked, " that there should be four or five smaller schools connected with the general science schools, which are distributed all over the country, than that there should be one school situated in London?" " I unquestionably say so," the witness replied, " and the example of foreign countries bears me out. You have in Brussels the head school of Belgium, but you have others in that country; you have one at Louvain, and another at Liege, and probably others. In like manner in France, besides several schools in Paris, you have others in the provinces."* The propriety of doing in England what Sir Lowthian Bell recommended does not need to be questioned, but the circumstances of England and Ontario are widely different. With us the industry is only in its infancy, and we have few trained men to fill any place requiring superior skill, either in mining or smelting or manufacturing works. One school well equipped would serve our present needs, and nowhere else could it be so economically established as in connection with the Practical Science department of the state University. It may be necessary, even in the near future, to extend our facilities and open other schools where more of the art and less of the science of mining and metallurgy could be taught. If capitalists cannot be induced to erect iron furnaces or silver, copper and nickel refining works, it may be deemed advisable by the government to demonstrate the practicableness of such enterprises. This has been done in one or two of the Australian colonies and elsewhere, and if the scheme were adopted here a government furnace and refining works might be utilised in giving instruction to students and others at convenient seasons, extending the course of study cautiously as the call for it might warrant.

Present needs in Ontario.

Byron E. Walker—I am general manager of the Canadian Bank of Commerce, and reside at Toronto. I have paid some attention to geology. I have collected for many years past the reports of the surveys of the states of Minnesota, Wisconsin, Michigan, Illinois, Iowa, Ohio, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Alabama, Tennessee, Missouri and California. I have the complete reports in almost every instance, but there may be a few recent ones which I have not yet got. I wish to state to the Commission my views regarding the pressing necessity for a complete geological survey of the province, showing its resources not only as to its minerals but as to every kind of raw material we possess apart from the products of agriculture. I think anything short of a full survey of every county in the province and the examination of our entire geological resources would be a great mistake economically, and I will endeavor by comparison with the neighboring states to show what has been done and what is being done by other peoples situated similarly to ourselves. As early as fifty years ago the more progressive of the governments of the several states in the United States began to examine their natural resources with a view of demonstrating to the people the extent of their wealth in raw material. Reasonably complete surveys at this time were made of the states near the Atlantic coast, such as Massachusetts, Maine, Connecticut, New Hampshire, Virginia, the Carolinas, etc. At the same time the less settled middle and western states made

Necessity for a geological survey of the province.

The example of neighboring states.

*Report, vol. III, p. 27. Of the practical value of scientific education to young men in the iron trade Sir Lowthian Bell said: " I think the necessity of some scientific education is now so generally recognised that a young man in a few years will have a difficulty in obtaining employment if he has not been scientifically educated. If you will take, for example, our ordinary blast furnace work, science has taught us the quantity of heat which different kinds of fuel are capable of evolving under different conditions; we have been taught also, chiefly through men whose minds have been devoted to abstract science, the amount of heat which is required in every part of the smelting process of iron. It must be and is no doubt a great advantage to have a man connected with the management of the works who has been thoroughly grounded in these somewhat abstruse philosophical questions, and I have no doubt at all that before long such a scientific education as it involves will be considered a *sine qua non*.—Vol. III, p. 25.

rough surveys indicating the general features of importance in each state ; while New York began a series of reports upon its natural history which, commencing in 1837, are not yet finished, and are recognised all over the world as a magnificent evidence of the intelligence and wisdom of its people. It is to be noticed that the federal government was not at this time doing anything in a regularly ordered way, although many valuable reports in connection with expeditions across the continent, the examination of lands for settlement, and subsequently the building of the Pacific railways, were published under authority of different departments of the government at Washington. It was not until the department of the interior commenced what is called the geological and geographical survey of the territories, about 1867, that the federal government can be said to have taken up in a distinct way the matter of carrying on surveys, and these it will be noticed are of the territorial possessions and not of any of the states. I mention this fact because the opinion has been held by some parties that it is the duty of the Dominion government to furnish such information for all parts of Canada, and I think it cannot be made too clear that the Dominion government is not likely to do anything of the kind for a province as wealthy as Ontario. These early American reports are not very different in kind from that made by Sir William Logan in 1863, except that they are often much fuller in details. They were made at a time when the knowledge of geology was much less perfect, when few railroads had been built, and the work of field geology was in every way more difficult than it is now. Nevertheless the value of these reports to the various states in inducing settlement and in creating enterprises of many characters depending on raw material is incalculable, and the reports themselves are today regarded as invaluable by those who are fortunate enough to possess them. A few years after the war the wealthy states of the northwest and west also began the preparation of reports which set forth the natural wealth of the particular states in a manner rendering it comparatively easy for any capitalist to ascertain without difficulty the resources of a particular county, or the various points in the state where a particular substance in which he may be interested is to be found. In the survey of the state of Michigan, begun in 1869, I find that in addition to volumes on the iron-bearing and copper-bearing rocks and other ores we are supplied with numerous analyses and with superb maps of actual mines in operation, as well as of mining districts ; the report also gives information as to the distribution of forest lands, soils of the various parts of the state, localities where stone for building purposes may be obtained, clay for brick-making, sand for glass-making, gypsum, hydraulic cement rock, slate, etc. Numerous analyses are also given of salt wells, chapters on the material and cost of barrels, and other information in connection with the making of salt, and statistics as to the cost of working many other materials. With reference to the salt industry, I may say that while residing at Windsor it came to my knowledge that very many numbers of the third volume of the Michigan reports containing information regarding the salt industry came into Canada for the use of our own salt producers in the Goderich and Seaforth districts, much of the information being as useful to Canadian as to American producers. The survey of the state of Ohio begun in 1873, and of the state of Illinois begun in 1866 and already extending to seven volumes, provide a separate geological map for each county. The natural drainage, surface features, geological structure and resources of every kind of each county are treated separately. As a consequence we notice that almost as much attention has been paid to the matter of building-stones in Ohio as to the matter of coal, although anyone living out of the state might naturally suppose that the latter product would be given much the greater importance. Of the north-western states, Iowa, Wisconsin and Minnesota have published somewhat similar reports. It would be impossible to adequately describe here the survey of the state of New York. It is divided into several departments of natural history, having among the number one volume devoted to mineralogy, four volumes to geology and seven or eight (published during the last 45 years) to palæontology. These reports are the foundation of all geological knowledge in North America, and render the work to be done in this province much less difficult by the information already stored up in them. It is probably well known to the Commission that almost every state of any commercial importance in the United States has made a more or less complete survey. I have not attempted to enumerate them, but I invite the Commission to examine my collection of reports if they desire to do so. The state of New Jersey in connection with its survey has recently completed an atlas in seventeen very large maps, in which every variation in elevation of 100 feet is given. It is not to be supposed that the province of Ontario will be able to do such a thing for very

Surveys made under direction of the federal government in the territories.

Practical value of reports.

Surveys in the north-western states.

The Michigan survey.

Report on the salt industry.

Surveys of Ohio Illinois and the north-western states.

The survey of New York state.

New Jersey geological atlas.

many years to come, but when we consider that the possession of such an atlas would enable an engineer to plan a railroad without further assistance the value of it can hardly be over-estimated. While residing in New York the inconvenience of not having a survey of the province was frequently brought to my notice. In our banking business there we give credits for the importation of phosphates into the southern states, where they are used for improving the cotton lands, and our business also brings us into contact with wealthy southern capitalists. In meeting southern merchants they have often asked me if it were true that there are phosphates in Canada, the question indicating that if in Canada at all they might be anywhere between Nova Scotia and British Columbia. The state of Pennsylvania publishes a great number of monographs in such a convenient shape that anyone can obtain a report regarding the whereabouts of any particular mineral in the state. Now if there were such monographs or other reports of the province, it would have been a simple matter to direct those capitalists who were interested in phosphate mining to the public office where such reports might be obtained. I have had similar experiences with reference to many other of our resources, but this will suffice to show the direct practical value of a report. The state of West Virginia is a signal instance of how much is lost to the people by the authorities not acquainting them with the natural wealth of our own lands. It was a wild, mountainous region when Virginia was surveyed fifty years ago, and since it was made a separate state at the time of the war it has been too poor and unprogressive to have a survey made. Its resources must be almost identical with Pennsylvania, but for lack of acquaintance with these its invaluable timber, coal and mineral lands have passed into the possession of northern capitalists who went to the expense of prospecting on their own account. The Commissioners know much better than I do whether or not similar results are taking place in Canada to-day. I know of no intelligent and progressive part of the world where the attempt has not been made to place these facts before the people, and I trust that before many years Ontario will no longer be in the rear. I have so far spoken only from the point of view of the business man, representing through the institution I serve large interests in the province regarding the commercial value of a survey. But I would like to add a few words regarding the necessity for a report on the palæontology of the province. You are aware that no report on the geology, lithology, etc., can be made without a thorough examination of the fossil-bearing rocks, and it follows that a large part of the work of such a survey consists of gathering palæontological specimens, which should form the beginning of a great public museum. It may be argued that this province is not wealthy enough to concern itself with anything but economic questions at the moment, but the value to our educational institutions of a collection of fossils gathered in this province, one of the richest fossil-bearing portions of the globe, cannot be insisted upon too strongly. I have for many years been an amateur student of palæontology, and have a large collection, gathered mainly in Ontario. It is within my knowledge that during the last twenty years a very large number of specimens, which in many cases may never be duplicated, have been sent to Great Britain, Germany and the United States for examination by eminent men there, simply because we had no geologist in charge who could take an interest in such specimens. In naming the fossils in my collections gathered in the Upper Silurian and Devonian formations, I have for many years used the New York state reports, and as a matter of fact hundreds of illustrations in these reports are made directly from fossils obtained by the assistants to the state geologists from the counties of Haldimand, Welland, Lincoln, and Wentworth. The township of Bosanquet in the county of Lambton is a remarkably rich place for fossils of the Hamilton formation. Illustrations of these from actual Canadian specimens are to be found in great numbers in the Michigan reports and in the most recent publications of New York state. The only publication available to the Canadian student who has not access to these American volumes is a small report by Professor Nicholson in 1874-75. Sir William Logan's report of 1863 is comparatively useless for such purposes, and the palæontologist at Ottawa has published nothing of late years except a monograph on the Guelph formation in 1884; so that while we have been almost utterly unmindful of the treasures in our rocks, the geologists in charge of the surveys of neighboring states have visited the province and carried away invaluable specimens, and the various geological journals in Great Britain and on the continent have been busy discussing some of our most remarkable discoveries in palæontology. Some years ago a Canadian professor prepared drawings and descriptions with the nomenclature of several varieties of graptolites, rare and fragile fossils found in the shales of the Niagara

An illustration of the commercial value of a survey.

The case of West Virginia.

Scientific value of a survey.

Specimens sent abroad for examination.

Ontario fossils illustrating New York and Michigan reports.

Our losses from an educational point of view.

group at Hamilton, and after many efforts to get them published in Canada they eventually appeared as a monograph of the university of the state of Missouri. The same gentleman took the trouble to obtain from the various railways and to tabulate all the elevations which had been taken in the province of Ontario, making a pamphlet of 43 pages, representing a great deal of labor valuable to both geologists and engineers, and there being no medium through which this could be published in Ontario it forms bulletin No. 6 of the United States geological survey. Having very little time at my disposal I have only attempted to bring together a few facts from a non-professional point of view, but which seem to me to show sufficient reason for the establishment of a survey, with instructions to make in the first place a report somewhat similar to those made in the United States and in most European countries and British colonies; that is, a report covering in a series of volumes a survey of the entire surface of the province, to be followed thereafter, practically for all time to come, by occasional reports to be issued by a permanent geologist in charge, so as to keep our stock of knowledge always as full as possible, and on a level with that of other countries. One of the results which would doubtless follow from such a survey would be the establishment of a public museum, exhibiting our minerals and other raw material, and our remarkable series of fossils placed in a suitable building in Toronto, duplicate specimens being supplied to the larger public schools throughout the province. The commercial and educational value of this alone would repay the cost of a survey. Columbia College has supplied the west with experts in mining, and without the appliances they have in New York much that has been done in the United States could not have been done.

Scope of the work.

A public museum of minerals and fossils.

Columbia school of mines.

A. R. C. Selwyn—As to educating prospectors, I do not think the class of men who prospect are the men you can educate into scientific explorers; I do not think there is anything helps them better in prospecting than good geological and topographical maps, and I think the province would do well to get up a good map. Prospectors have a good idea of what they require. Collections of specimens such as we have at the museum here help explorers a great deal. There should be a mining engineering course in connection with the universities. I think every university should have a course in natural science. I also think that compulsory returns of the output of mines and of the work done would do good. In Nova Scotia it is done, and is found to have a good effect. It has not hindered development there. It may injure what is called a boom, but that is never desirable, and generally results in loss to someone. The main object of a government geological survey should be to ascertain the facts, whether favorable or otherwise, and state them truthfully and impartially.

The use of geological and topographical maps and specimens.

Statistics may injure a boom, but that is no loss.

B. T. A. Bell—The institution of a school of mines would undoubtedly result in a great deal of good, but I doubt whether the industry is far enough advanced for that yet. I think the establishment of small local museums where mineral specimens could be seen and examined and information gained would do a great deal of good. Lectures and instruction with the blow-pipe during the winter months might also be introduced with advantage. I think there should be compulsory returns of output made to the government. The information collected by the Geological Survey is already doing a great deal of good, though the equipment of the statistical section is by no means complete as yet. It would be in the interest of development to establish a bureau of that kind in Ontario. There should be a law compelling mine owners to give such statistics, and the statistics should also be readily accessible to the public at all times in the government offices. Such a bureau would be an assistance to mining men, prospectors and capitalists. At present the great difficulty is to find out what information about mineral properties or mines is to be relied upon. Some parties give information willingly, others will not, while others again will lie. The only way I can find out about the quantities mined and shipped here is by going to the stations and the custom houses.

Local museums of mineral specimens.

Lectures and statistical information.

An assistance to mining men, prospectors and capitalists.

David Boyle—My connection with mining has been altogether of an educational and not a practical character. I think it would be highly advisable to establish a school of mines. If we had but the one school I think Toronto would be the place to have it. The largest number of visitors and people come here, and it is the business as well as the educational centre of the province. A chemical course in connection with the high schools might do a great deal towards preparing young men to take a course of this kind. I think every high school should be provided with specimens and illustrations of the different formations, metals and minerals. A stamp mill would be required in a school of mines. Analyses of specimens are

A school of mines advisable.

Chemical course in the high schools.

Stamp mill. very misleading, as samples are generally picked. To ascertain the true richness of an ore requires the reduction of several tons. The cost of a mill is from $1,000 to $1,400 a stamp. I think about a six-stamp mill would be required. I do not know what the cost of establishing a school would be. It might be an attachment of the university or of the school of practical science. I believe it could be established at from $20,000 to $30,000. I was at Cincinnati in connection with the Ontario exhibit. That exhibit attracted a great deal of attention, and it opened the eyes of a good many of our own people. Business men, men connected with the iron industry, and with other metals, were led to make inquiries concerning our resources. It seems to have been taken for granted till recently that Ontario was nothing but an agricultural country and the Dominion geological survey has neglected it almost altogether. With the means at their disposal and the enormous territory they have to attend to it cannot be expected that Ontario should receive the requisite attention. I think it would be well therefore for Ontario to have a geological staff of her own. The wisdom of sectional surveys has been shown by the reports of several of the American states. They give a good deal of attention to natural history, biology and archæology. I think an appropriation of from $15,000 to $20,000 would do a great deal for a collection in those fields. A museum might be formed to include minerals, timber, etc. I think most attention should be paid to the economic minerals, but there is no reason why, when a man is starting upon a geological tour, he should not be requested to keep his eyes open to biological facts also.

An Ontario geological survey staff.

A provincial museum.

Lack of scientific knowledge.

W. H. Plummer—A great many of the prospectors lack scientific knowledge, and I think it would do good if the government sent a skilled man to deliver lectures during the winter at all mining centres. I do not think the government ought to put up stamp mills; that is a matter of supply and demand, and should be so treated. I think it would be a good thing to have an office with specimens here so that prospectors could compare them with any rocks, ores or minerals they might come across.

Specimens for comparison.

A great want of knowledge.

Wm. A. Allan—A school of mines would be a very good thing indeed. There is a great want of knowledge of mining here; there is no knowledge of the formation and occurrences of the rocks. It would be well to make it necessary that a mining captain should hold a certificate of competency, and there should be a department for the issuing of such certificates. Lectures to prospectors would also be valuable. The majority of men here can tell phosphate when they see it, and that is about all. I think it would be well to have a law compelling the return of statistics; it would do away with a great deal of deception that is practised.

Lectures and statistics.

S. J. Dawson—I think it would do good to have a course of lectures delivered to prospectors, especially if in connection with a test mill and an assay office. I think the collection of mining statistics and the circulation of the information would be highly desirable, and would lead to a great deal of good.

D. W. Butterfield—My home is at Waukeegan, Ill. I have had between six and seven years' experience in gold mining and milling, particularly in the Black Hills district. I have held the position of superintendent of the Vermilion company since the 1st of April this year. Within the last two or three years a school of mines has been established in Rapid City, Dakota, about 50 or 60 miles from the mines. The pupils are taught assaying and chemistry, and they have small mills for working ores of different kinds for testing and experimenting with them. Charges are made for assaying to make it as nearly self-sustaining as possible. Mineralogy is taught, and there is a regular course for the students. I think the course is either two or three years. The school is well patronised and is doing good work. After the students go through the course they are supposed to be mining engineers and experts and to be able to report on mines, to handle different ores, to know the nature of them, etc. I think a course of lectures to prospectors at a low rate would have a very beneficial effect on prospecting; if such lectures were given in the principal mining centres I think they would be well attended. In Dakota the government publishes statistics of mining; they send round an officer to the different mines to collect the information, and then it is published by the government. I think they publish the statistics of each mine separately, and they have the power to compel answers to questions. From my experience the publication of such statistics is of great service.

Dakota school of mines.

Lectures to prospectors.

Mining statistics in Dakota.

Sir James Grant—I think a school of mines would do the greatest good. It would turn thought in that direction, and young men would take to the mining business instead of studying medicine and law, professions which are very much

Special instruction needed in building up a new industry.

overcrowded at the present time. The erection of stamp mills would be also a good idea, as also would lectures to prospectors. I think there should be compulsory and accurate returns of mining statistics made to the government. That would induce capital to be invested by giving capitalists confidence.

D. E. K. Stewart—I think as a matter of public interest and information it would be well to have mining statistics collected and published. I think it would tend to the development of the mining industry. I would approve of making mining returns compulsory by law. Statistics would aid the mining industry.

John Galbraith—I am professor of engineering in the school of practical science. I have given a good deal of consideration to the question of technical education as connected with mining. Mining engineering, as far as I understand it, is about as indefinite as civil engineering. Men are employed who lay out shafts, levels, etc. : that is mining surveying, and it can be taught in the school as well as anywhere else. The rest of the mining engineer's work is done under the captain or the superintendent, such as the arranging for tunneling, excavating, and the practical work generally. Personally I do not believe in a great deal of what they call the practical work in an engineering course. I do not touch any practical work connected with blasting, excavating, or anything of that kind. I look upon it as a waste of time. I think the student should be taught everything he cannot acquire on the works afterwards, leaving the practical part to himself. Nearly all the students who have taken the course with us are engaged on railways, canals, and on city work. I do not know of any that are employed in mining. In the regular civil engineering course they take the elements of mineralogy and blowpipe practice, but they do not go into assaying. Two or three have taken the ordinary engineering course and added assaying. A mining engineer must be a civil engineer. He should know the geology of minerals ; he should know the use of the blowpipe and something about assaying, and he should know more especially the preparation of minerals for the market. That could be taught under the roof. The requisite machinery could be erected and its use taught in the school. I have been at Columbia College, where the mining course is a civil engineering course combined with mineralogy, assaying, and the preparation of ores for the market. The course at the Boston school is about the same. Lectures to prospectors at mining centres could be given at small expense. Arrangements could be made with the local assayers to form a little school, and that might do a great deal of good. The professors could deliver lectures when possible, but the only time they could get away would be during vacation. The members of the Geological Survey might also be able to do a little of that kind of work.

Mining surveying and engineering.

Practical work a waste of time for the student.

A mining engineering course.

Lectures to prospectors.

Æneas McCharles—The erection of a stamp mill for the purpose of testing ores would be a benefit ; a small fee might be charged which would go towards paying the expenses. The establishment of a school where prospectors might learn a little geology would I think be a great help to prospecting. I think it would be a good thing to have lectures delivered in mining centres during the winter time. Stamp mills, schools and lectures.

Thomas A. Towers—Where there has been a discovery I think the government should use the diamond drill ; I think it would be a proper expense to charge upon the property. Part of the tax on the land should be used for encouraging the mining industry. A local assay office and the erection of a small custom mill by the government would be a great benefit. A course of lectures delivered at mining centres would also do good, inasmuch as it would bring a higher class of explorers into the country. A good collection of rocks for the prospectors to examine and compare would also be of considerable benefit.

A government diamond drill.

Assaying and lectures.

Henry Ranger—I reside at Mattawa. I am one of the original shareholders of the Vermilion Gold company. My business was formerly that of a bush-ranger, but for the last two years I have been prospecting in this country. I have discovered minerals in Denison. I discovered in the first year copper on lot 12 in the 4th of Denison, on 1, 6, 8, 9 and 11 in the 5th, and on 8 in the 4th. The second year I discovered gold on 7 in the 4th and gold and copper on 6 in the 4th. I discovered a quartz vein with gold and silver on 5, and on 1 in the 4th a quartz vein with gold. In Graham I discovered iron pyrites on 12 in the 3rd and a quartz vein containing copper, pyrites and galena on 12 in the 4th. In Snider on 12 in the 6th I found copper. That is all. I had no previous qualification for the work. I think it would be a great advantage to the prospector to be instructed as to the metals and the rocks ; it would have been to me. I got instructions the second year from the man that brought me to prospect for him, Mr. McConnel, and I found it of great

A gold and copper prospector's opinion.

use to me. I was the first to discover gold in this part of the country; this was on the 3rd of September, 1887, on lot 6 in the 4th of Denison.

Instruction at mining centres.

James Stobie—The giving of a course of instruction at the mining centres would do a great deal of good, and I think many would attend them. A good collection of rocks for prospectors to compare with would be a great help.

Instruction for prospectors.

Robert McCormack—It would be a good thing for prospectors to have a place where they could get instruction; I for one would spend all my spare time there.

John Babcock—A system of instruction for prospectors would be a great boon, and they would take advantage of any such provision.

Necessity for instruction.

Francis Andrews—The ores here are different from any other place in the world, and I think a school of mines would be a good thing so as to teach young men to handle them properly.

An equipped mining school.

Peter McKellar—I think a mining school established at Port Arthur would be a good thing. It would be well to have a small test mill and concentrators, and to have a chemist to assay the ores. The whole establishment, buildings and all, could be erected for $20,000.

Test mill and

School of mines.

James Conmee—I think it would be a good thing for the government to establish a mill, as has been suggested, or perhaps it would be better to bonus a company. At a cost of about $75,000 moderate works could be put in operation, and I think they could be made nearly self-sustaining. I am figuring on a twenty-stamp mill, and such an establishment as they are aiding in the States. This twenty-stamp mill would be large enough for practical work as well as testing. There should also be a furnace to treat ores. The government should charge the actual cost of treating to those who brought their ores, and make it as far as possible self-sustaining. There should be a school of mines in connection with such an establishment; that would give the students a good practical education, so that after they passed they would understand the practical running of a mill. At present they are nearly all foreigners at the head of mining enterprises in this country.

School of mines and experimental works.

W. H. Laird—I think the government should treat the mining as they have treated the agricultural industry, and establish a school of mines and experimental works. A course of instruction to prospectors here would do a great deal of good. The country is not properly explored at all, new discoveries are being made every day, and when the country is covered with timber exploring is a very difficult matter; therefore the government should do all possible to encourage the prospector.

A school of mines would supply skilled

Test mills and assay office.

D. F. Burke—A school of mines established here would be a great benefit; it would supply the demand for skilled men. A great sum of money is every year wasted by people going into mining who do not really understand what they are doing. The erection of mills would also do a great deal of good; it would enable people to take fair samples of their ores and have them more satisfactorily tested than is possible by sending a small piece to get assayed. I think it would be a good thing for the government to appoint an assayist who should only be allowed to charge a nominal sum, say a dollar, to make an assay. If that were done twenty assays would be made for every one that is now.

The Michigan school of mines.

Thomas Hooper—A mining school would be a great help to the mining industry here, but the first and most important thing to get is a railway. The state of Michigan has established a school of mines at Houghton, spending $90,000 for buildings and $25,000 a year for equipping and running it. It is well patronised; the fees are very light, just enough to pay for the light and chemicals used. This school is in its third year now. A class of six will get their diplomas this fall, and they have contracts with companies to go to work as soon as school is out. Civil engineering, mining engineering and assaying are taught. Prospectors can obtain knowledge without going through the whole course. I have two sons who have been attending the Michigan agricultural college, and it is my intention as soon as they get through their course there to give them a year at the mining school. They have a good staff of professors; I think they pay the principal $5,000. Students from the state are admitted free, but have to pay about $30 for the chemicals for the three terms. The establishment of smelting works would be good, but I am not sure that it is not a little too soon yet. But above all things a railway is what is required; with a railway development would be done that without it will take years. I do not think you would have to call upon the government for smelting works if they would give us a railway. I think there would then be capital enough found to build the smelting works without troubling the government.

T. H. Trethewey—There are very few mining men in Canada, and I think the establishment of a mining school would be a good thing. A felt want.

Henry H. Nicols—No doubt the establishment of smelting works here would be a great advantage. They are in operation at Puebla and five or six other places out west. The city of Puebla gave a bonus of $100,000 and the land in order to secure the smelting works. I think that here, as it may be sometime before private capital will establish them, it would be well for the government to take the matter in hand. In Colorado we have a school of mines and we find that it is an advantage. I think it would be well for this province to establish one too. If such is to be established I think it would be better to establish it in the mining regions. Puebla smelting works. Colorado school of mines.

William Murdoch—The establishment of a stamp mill, where the poor man might have his eight or ten tons put through and get his money for it less the charges, would I think be a very good thing; it would enable him to realise and go on with his work. I got a letter from a gentleman that he would put up the machinery if the government would help to some extent. The town of Port Arthur has passed a by-law to exempt such works from taxation for ten years. It is advisable to have reduction works separate from the smelting works. To establish reduction works would take about $60,000 or $75,000 of a bonus. For sample works $5,000 of a bonus would get them here at once and they could be put up this fall. I think a mining school is a most important thing; all our failures have been through want of knowledge. Lectures to prospectors would also be very useful. I think Port Arthur would be the best point at which to establish a mining college. Stamp mill and sample works. Failure a result of want of knowledge.

John C. Haskins—A mining school would do a great deal of good, and stamping and reduction works would be most useful.

Alexander Matheson—A requirement of first class importance is a stamp mill to help development work. In my opinion this would be the making of the mining interest in the Lake-of-the-Woods district, especially if it was established and carried on as a government work. A stamp mill needed to promote development work.

E. B. Fralick—I think the establishment of works by the government would tend to cause development of the gold properties in the Hastings district. People have told me they were aware of the existence of mineral deposits, but they would not tell where as they said they could not do anything with them. Government works, such as stamp mills, would induce such people to locate their finds and go on and develop them, besides setting more men to prospecting. A school of mines would also do a great deal of good. The want of technical knowledge has been one of the chief causes of failure, and were such a school established a large number of young men would take to the business and it would be a great benefit. Except for iron this section of the country has never been properly explored. A course of lectures to prospectors and a collection of specimens for making comparisons would be of excellent service. Want of technical knowledge a chief cause of failure.

Joseph Bawden—I don't know that any advantages would accrue to the iron trade by educating the prospectors; no doubt there are many great deposits that have not yet been discovered, but there is enough discovered and in sight to last for a long time. There is a very large mining section back of Kingston and I think we might have here, in connection with our university or otherwise, a school of mines. There will be a demand for mining engineers, and a large part of their education should be gained by visiting the mines and examining the ores. In connection with the department of agriculture we should have a bureau of mines. I think it would be greatly to the advantage of the country in general and the province in particular if instruction was given in the high schools on the subject of mineralogy and mining engineering. Our lack of information as to the geological formation of the country is very great; scientific men are required. A school of mines.

William Caldwell—I think it would be a wise thing if the government had a diamond drill and worked it in places. If any minerals or ores were found it would pay the government; in any case the government should stand the chance. The ores placed in the museum would be of great value in many ways. What is wanted in this country is practical education, and I think a school of mines would be the right thing. Any expenditure in that direction would be money well spent. Practical education is the need of the country.

James Bell—A school of mines would do a vast amount of good. There is a great deal of ignorance concerning mines and minerals generally, and mines are worked largely in the dark. Ignorance concerning mines and minerals.

B. E. Charlton—I think a school of mines would be a great boon to the province. Many men engage in mining without the requisite knowledge, and after A school of mines would be a great boon.

spending a large amount of money they leave it in disgust. The character of the mining puzzles strangers in this country. We are in want of skilled men.

A. J. Cattanach—A school of mines would do an immense amount of good. There should also be places where ores could be analysed and tested.

William Ward—Capital is difficult to procure because as a rule mining operations in Canada have not been successful, failure being generally the result of bad management, and in some instances on account of a too limited market. One of the great wants of this country is skilled miners. It is found that miners coming from other countries are altogether puzzled when they get to the north shore. Geologists have said that there was no gold on the north shore; now it has been found, but it is impossible to say in what quantity. The establishing of a mill where a large quantity of ore could be tested and the value ascertained would I think do a great deal of good. I have very little faith in assays of small specimens. Such a mill might be in connection with the school and the government might have the right to retain the product of the ores sent to them, and that might help to defray the expenses. A school of mines might be established in connection with the university. A great deal of loss is entailed by want of knowledge. A thorough geological survey of the province would be useful.

The want of skilled miners.

Test mills.

George A. Shaw—The government might do a great deal of good by bonusing or putting up smelting works and an assay office. The works should be put up in a central point in connection with a school where young men could be trained. Toronto would be a central point. All our mining engineers now come from the States; there are none here. I do not believe in assays, and I think there should be works where ten tons could be tested. The necessary reduction works with stamp mill could be put up for about $25,000. A ten-stamp mill would cost about $10,000. There should be a good assayer and chemist and he ought to have all the best appliances.

Smelting works, assay office and mining school.

Arthur Harvey—I do not think a school of mines is to be looked upon as an assistance to practical miners. I think the mines have been properly worked in the lake Superior district, and that there has not been a want of skill and intelligence. Take the case of the East Silver Mountain mine: an American company, not finding silver after expending $15,000 abandoned it. An English company took it up and have spent $100,000, and they have not yet got any silver. I think that shows that the American company acted wisely. The Badger, West Silver Mountain and Beaver are carried on with energy and skill; of course mistakes have been made, but mistakes will be made under any management. A bonus for the erection of treating works at Rat Portage and Port Arthur would do good. In three years they would begin to pay, and then the government could sell them. Now if two or three men get out ten or twenty tons of ore nothing can be done with it. Works at a central point, easy of access, would be a great boon.

An exceptional opinion.

Treating works at Rat Portage and Port Arthur would be a great boon.

E. B. Borron—There is a larger class than either the explorers or the capitalists specially interested in the development of our mineral resources. I refer to the miners—all employed in the various operations of mining. It is important that miners generally should be able to acquire such knowledge as will best fit them for the intelligent performance of their duties. It is from this class that in times past mine captains, agents and overseers of the different departments have been taken. To one contemplating making the extraction of ores from the earth or mining in its limited sense a speciality some knowledge of geology, mineralogy, mechanics, the use of such instruments as the miner's compass or dial and level, etc., and mensuration and drawing in addition to a common school education, could not fail to be valuable. To the ore-dresser a knowledge of fewer subjects would seem necessary; mechanics, mineralogy and some little knowledge of levelling, drawing and assaying are all I think of on the spur of the moment as likely to be of particular use to him. To the smelter a special knowledge of chemistry, physics and mechanics is necessary. The best time for boys to acquire this knowledge is between the ages of 12 and 15. As miners generally make very good wages there are many between the ages of 20 and 30 who would be glad of an opportunity to improve themselves so as to qualify for higher positions. The places where such instruction should be imparted are the high schools or collegiate institutes most central and convenient to our principal mines. Sault Ste. Marie and Port Arthur would be points well suited for the lake Huron and lake Superior districts. There is at present one science master on the staff of teachers in all collegiate institutes, if not high schools; the addition of another, who might with

Instruction for miners, ore-dressers and smelters.

Instruction in the high schools.

advantage be a mining engineer, would probably be all that would be required. It is important to all concerned that the mineral statistics both in respect of quantities and values should be reliable, by whichever government they may be compiled. These statistics, till lately taken in a great measure from the trade returns, have been grossly inaccurate and misleading, as may be seen by reference to the report of the Geological Survey for 1887. It is there shown under the head of silver alone that there is a discrepancy of two or three millions of dollars in the value of the exports from lake Superior, as taken from the trade returns and other sources. To prevent extravagant and misleading valuations in the future, the officer of customs at the place of shipment should be placed in a position to check not only the quantity, but the quality and the value of the ores shipped or otherwise exported. He should be empowered to take average samples of such ores, and these should be assayed and the value arrived at. If the officers have not the right, the law shou'd be amended to give the minister of customs the power to confer the right.

Inaccuracy of customs statistics of exports.

Thomas Marks—I think the establishment of a mining school would fill a great want and do a great deal of good, especially in connection with smelting and stamping works. I think for about $30,000 or $40,000 something could be put up that would serve the purpose.

Mining school and reduction works.

W. H. L. Gordon—One thing that would do much good would be the establishing of places where assays could be made at less cost than at present. Assays are very expensive and it costs too much to find the value of specimens.

Assay work.

APPENDIX.

APPENDIX.

A.—MINERALS IN THE SUDBURY DISTRICT.

BY DR. ROBERT BELL, ONE OF THE COMMISSIONERS.

Since the first Section of the report was written considerable progress has been made in the development of the mineral wealth of the Sudbury district. Besides the Stobie, Copper-cliff and Evans mines, belonging to the Canadian Copper company, which have been steadily worked and have yielded a large amount of copper and nickel ore, two other mines have been in operation and some new localities have been discovered. The writer has had opportunities for further study of the geological and lithological relations of these deposits, and the following notes are added to bring the subject up to date. It will be seen from these that the copper and nickel ore deposits of the district resemble one another closely, and that they all appear to occur under similar geological and lithological conditions. Supplementary notes.

VARIOUS COPPER AND NICKEL ORE PROPERTIES.

The deposit which had been discovered on lot 4, range 2 of Blezard, about one mile north of the Stobie mine, has been acquired by a new organisation called the Dominion Mineral company, and is being vigorously worked. Three shafts are being sunk, each of which had reached a depth of about 40 feet in the middle of October. The ore consists of a body of mixed chalcopyrite and nickeliferous pyrrhotite mingled with more or less rock matter, giving the whole the appearance of a conglomerate. The general strike of the country rocks is here as elsewhere in the vicinity about northeast and southwest. The ore-bearing belt, which is associated with a dark quartz-diorite, is about 100 feet wide and dips north-west at an angle of 65°. It is overlaid by a massive bed of ash-colored greywacké, the weathered surfaces of which present raised reticulating lines. Immediately to the northwest of the shafts there is a dyke from 30 to 50 feet wide, of dark brownish gray crystalline diabase, weathering at the surface into rounded boulder-like masses, which scale off concentrically. At the place just indicated the dyke runs south 35° west (mag.), but a short distance to the south-westward what looks like its continuation runs south 70° west, and appears to be thrown a short distance northward by a dislocation. The Dominion Mineral Co's. property.

To the southwest of the Dominion mine similar ore has been found in the southern part of lot 5, in the 2nd range (Russel's), and also in the northern part of lot 6, in the 1st range (Stobie's) of Blezard. A large diabase dyke runs near the latter, and both discoveries are near the north side of a quartz-syenite ridge which runs in a north-easterly course from the township of Snider and appears to terminate before reaching the Dominion mine. The copper deposits of this mine, Russel location, Stobie location, Murray mine, McConnell mine, lot 10 in the 1st range of Snider and lot 1 in the 1st range of Creighton, would therefore all appear to be in the same run, on the northwest side of the syenite and gneiss belt, while the Stobie mine, the Frood lot (number 7 in the 6th range of McKim), the Copper-cliff mine and an outcrop of copper ore on lot 1, range 2 of Snider, and another on lot 7 in the 6th range of Waters, would occupy a corresponding horizon on the opposite or southeast side of the ridge. Parallel ranges.

The Murray mine, situated on the northern part of lot 11 in the 5th range of McKim and on the main line of the Canadian Pacific railway, 3½ miles northwest of Sudbury Junction, was prospected under a bond by the

Messrs. Henry H. Vivian & Co. of Swansea and London, and purchased by this firm on the 1st of October. At this locality the general strike is also northeasterly, and the ore body, which conforms with the stratification, is traceable for about a quarter of a mile. A short distance southwest of the railway track, which crosses the north-eastern part of the deposit, it has a width of upwards of 100 feet. Here as elsewhere the ore is a mixture of chalcopyrite and nickeliferous pyrrhotite, with incorporated masses of rock of all sizes, the deposit being in fact in all respects like those of the Stobie, Dominion and other mines. It is flanked on the northwest side by a very crystalline massive gray diorite, and on the southeast side by a dark greenish mottled variety of this rock, followed by alternate belts of more or less fissile amphibolite or hornblende rock and reddish gray quartz syenite. Ten of these alternations occur in a breadth of 150 yards. A cutting on the railway at about this distance southeast of the mine shows what may be either a conglomerate or concretionary mixture of these two rocks. The main ridge of quartz-syenite lies about half a mile to the eastward. A large dyke of crystalline diabase, with a west-north-western course and weathering into rounded masses, may be seen on the railway just northwest of the mine, and again to the eastward a short distance north of the track. This and a parallel diabase dyke are seen in other places along and near the track between the Murray mine and Sudbury, and similar dykes occur on Ramsay lake, which may be continuations of these.

The Murray mine.

Diabase dykes.

Late in the summer a discovery of mixed chalcopyrite and pyrrhotite, of which large and fine specimens were shown to the writer, was made at a spot situated about three-quarters of a mile northeast of the bay of Wahnapitæ lake, lying on the north side of the point and ridge between the east bay and the main lake. The deposit, which is said to be large and promising, is flanked by diorite on the southeast side. Those who discovered this ore-mass state that the surface indications consisted of nothing more than a black discoloration of the rock, and that it might have been easily passed over unnoticed. Another discovery of mixed chalcopyrite and nickeliferous pyrrhotite was made at the northeast end of Waddel's lake, which is the first of the small lakes on the canoe-route west from the western extremity of Wahnapitæ lake. The ore occurs in diorite, which comes in contact with quartz-syenite about half a mile to the south. Copper and iron pyrites, said to be nickeliferous, have been discovered on lot 3 in the 4th range of Levack. No work had been done at this locality at the time of the writer's visit, but the surface is covered by oxide of iron in the same way as at some of the other copper and nickel ore deposits of the district. The rock on the east side of the deposit is gneiss and on the west diorite. Similar ore is reported to have been found on lot 6 in the 2nd range of the same township, but the locality was not visited.

Discoveries in the region of Wahnapitæ lake.

The copper deposit opened by the Vermilion Mining Co. on lot 4 in the 6th range of Denison, and that of the Krean location about a mile to the north of it, are both associated with brecciated diorite rocks, as well as the Coppercliff and the Stobie, while gneiss or quartz-syenite occurs at a short distance to one side in every case. A deposit of copper ore similar to these occurs in the southwest corner of Snider (lot 10 in the 1st range), which is said to be associated with diorite and flanked on the south by syenite. At this locality there is also said to be a large dyke of crystalline diabase, weathering into the characteristic rounded boulder-like masses.

The Vermilion and Krean locations.

It will be seen from the foregoing that all the deposits of nickeliferous copper ore of the district which have been examined occur in diorite rocks, and further that in most cases the diorite is brecciated or holds angular and also rounded fragments of all sizes of rocks of various kinds, the prevailing varieties being other kinds of diorite, quartz-syenites, crystalline schists,

Occurrences of the nickeliferous copper ores in diorite.

greywacké and quartzites. The general geological position of these ores is therefore in diorite, and more especially brecciated diorite, with either gneiss or quartz-syenite near one side. The ore masses further resemble one another in having an approximate lense-shaped outline, parallel to the general strike of the country rocks, although they may not always be strictly conformable with them in dip, but may take a different angle to the horizon, as if they had been connected with longitudinal fissures and were of the nature of great brecciated veins or "stockwerks."

The occurrence of dykes of crystalline diabase near several of the deposits of copper and nickel ore has been referred to. Some of these dykes run west-northwest, others southwest, and one at the outlet of Ramsay lake runs about west, or towards the Copper-cliff mine. These dykes cut through all the stratified Huronian rocks of the district, and also the quartz-syenites, whether they occur as narrow bands or large areas. They are therefore newer than any of these rocks, and they are found on microscopic examination to be apparently identical with the diabase overflows of the Animikie formation of lake Superior. Their association with the ore deposits of this district suggests some connection with them; and it may be found on fuller investigation that where they cut the ore-bearing belts they have had something to do with their enrichment at these places. If this should prove to be the case it will be important to trace these dykes, as well as the stratigraphical horizons along which the metals may have been originally deposited in a diffused form, as new discoveries may be looked for at these intersections.

Age of the diabase dykes.

The smelting furnace which had been erected at the Copper-cliff mine towards the close of 1888 has been steadily in blast and has reduced an average of about 125 tons of roasted ore per day, the amount sometimes running up to over 150 tons. A second smelter in every respect like the first, which was erected during the past summer (1889), commenced work on the 4th of September, and has now been running with equal success for two months. The Dominion Mineral company and the Messrs. H. H. Vivian & Co. are erecting similar furnaces at their mines.

The smelting works.

THE GOLD DISCOVERY ON LAKE WAHNAPITÆ.

The gold mining location on the south side of lake Wahnapitæ was again visited in the month of October of the present year. Some work had been done, and the true nature of the auriferous rock may now be studied to more advantage than when the locality was visited last year before the ground had been broken. An excavation measuring about 20 feet in length by 8 feet in depth and the same in width had been made. This opening shows that the gold-bearing portion of the ridge of felsitic quartzite follows a belt of quartzite boulder-conglomerate which runs south-westerly. Some of the individual masses are sub-angular, but most of them are rounded, and they vary from a few inches up to ten feet in their greatest diameters, which are parallel to the walls. A few rounded greenish, somewhat schistose masses are also included, and all are packed closely together. The interstices are filled with a rather coarse glossy, greenish to yellowish gray hydro-mica or talcoid schist, which on weathered surfaces is seen to be full of pebbles of bluish quartz and white quartzite, from the size of coarse gravel down to that of pease or smaller. The quartzite boulders vary in texture from granular to compact or cherty. In color they present shades of light, dark and reddish gray; also of greenish or olive gray. The last named contain bunches of crystals of mispickle. In the width of the excavation there are four or five veins of white quartz from two to three inches in thickness, or aggregating about a foot. These show specks or small nuggets of free gold, and Mr. Richardson, the manager of the mine, informed the writer that he had detected visible gold also in the schistose filling as well as in the quartzite

Nature of the auriferous rocks on lake Wahnapitæ.

itself. A band of fine-grained, dark-colored diorite runs parallel to the quartzite ridge at no great distance on either side of it. That on the north-west side appears as if it had flowed upon an uneven surface of lumpy quartzite. An attempt to extract the gold from the quartz in this locality by means of a small arastra had been commenced at the time of my visit. The quartz was first calcined in a wood fire, after which it was easily ground under the flat surfaces of two large stones attached to a beam drawn round by a horse. These stones worked upon a smooth pavement of smaller ones, surrounded by a circular wall which held in a few inches of water with some pounds of quicksilver in the bottom.

B.—APATITES OF CANADA.

BY R. A. F. PENROSE, JR.

Discovery of phosphates in Ontario.

Phosphates were discovered in considerable quantities in Canada before the middle of this century, and were described by Dr. T. Sterry Hunt in the Canadian Geological Survey reports for 1848. Shortly afterwards they were mined in the counties of Lanark and Leeds, Ontario. But the first regular mining operations of any considerable importance were begun in 1871, in the townships of Buckingham and Portland, Ottawa county, Quebec, where apatite had been discovered several years later than in Ontario. The first company to operate on a large scale here was known as the Buckingham Mining company. It worked successfully until 1875, when a sudden fall in the prices of the phosphate market led to a stoppage. For several years after this the mines were worked by private parties, until in the years 1881 to 1883 the large mining companies which now control the richest properties in Canada were organised. Many of the phosphate properties in Ontario have been worked by the so-called "contract system." Under this system the farmers of the neighborhood, whenever they are without employment, blast out a little phosphate. The result of such a method is, of course, that the whole of a property is soon cut up with small pits and trenches, rarely exceeding twenty feet in depth and often interfering considerably with later and larger mining operations.

Mining operations.

The contract system.

THE ONTARIO AND QUEBEC DISTRICTS.

Ontario and Quebec districts.

There are two principal districts in Canada where apatite occurs in considerable quantities. The first is in Ottawa county, province of Quebec. It consists of a belt running from near the Ottawa river, on the south, for over sixty miles in a northerly direction, through Buckinghom, Portland, Templeton, Wakefield, Denholm, Bowman, Hincks and other townships. The belt probably stretches still farther to the north, but the country in that direction has been but little explored and is scarcely known except to trappers and Indians. The belt averages in width from fifteen to twenty-five miles. The second phosphate district is in Ontario, principally in the counties of Leeds, Lanark, Frontenac, Addington and Renfrew. This district is much larger than that of Quebec. But the apatite is much more scattered, and though special deposits are in some places much more continuous than those of Quebec the mineral has not yet been discovered in such large pockets as occur in the latter district. The belt which contains the deposits runs from about fifteen miles north of the St. Lawrence river in a northerly direction to the Ottawa river, a distance of about one hundred miles. It varies from fifty to seventy-five miles in breadth. The above mentioned districts are the regions where apatite has been found most plentifully, but it also occurs in other places, though so far as has been discovered in much smaller quantities.*

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*Lately it has been found that apatite is very generally distributed in Pontiac county, Quebec.

The apatite occurs in the upper part of the Lower Laurentian formation, the horizon being characterised by large quantities of pyroxene rock. The principal phosphate-bearing band consists of quartzites, gneisses, schists, felspar and pyroxenic and calcareous rocks, having an aggregate thickness according to Vennor of twenty-six hundred to thirty-nine hundred feet. All the beds are more or less completely metamorphosed, being sometimes indistinctly stratified and at other times massive and with no traces of bedding. The rocks, often contorted, all dip at a vertical or almost vertical angle. Sometimes the gneiss contains large quantities of mica and has a distinctly foliated structure. At other times it is impregnated with large quantities of pyroxene, as in the Quebec district. In the Ontario district this pyroxene is often replaced by hornblende of a dark-green, lustrous character. A highly garnetiferous gneiss is often found in large quantities in some of the apatite localities. In the Quebec district there is a series of trap dykes running in a general east and west direction. By some they are supposed to be connected with the occurrence of the apatite. But the trap is propably of a later date than the apatite, as it is sometimes found passing through pockets of that mineral.

Occurrence of apatite.

The principal difference between the country rock of the Quebec district and that of the Ontario district is, that the rocks in the latter region are often much more hornblendic than those in the former, and are often found in the form of a more or less hornblendic gneiss. The country in the Quebec apatite district is rough and mountainous. The hills are of a remarkably uniform height, rarely rising over five hundred to six hundred feet above the level of the neighboring Du Lièvre river. In Ontario, on the other hand, the land in Leeds, Lanark, Frontenac and Addington counties is low, and sometimes shows a smooth glaciated surface, covered by a thin layer of soil. In Renfrew county however the land is more hilly, and resembles that of the Ottawa district. As before remarked, the apatite occurs almost without exception in association with pyroxenic or hornblendic rocks. This rule holds especially true in the Quebec district, where the phosphate has never yet been found without being associated with pyroxene rock, possibly often of vein origin. This, called pyroxenite by Prof. T. Sterry Hunt, occurs in ridges running in a general northeast and southwest direction, following the general course of the strike of the country gneisses. It forms, together with a lilac-colored orthoclase, quartzite and trap, the mass of many of the hills in the phosphate district, while the stratified and massive gneisses are often seen bordering the sides of the ridges.

Country rock of the two districts

THE ASSOCIATED ROCKS.

The pyroxene rock is never found distinctly bedded, though occasionally a series of parallel lines can be traced through it, which while possibly the remains of stratification are probably often joint planes. Sometimes when the pyroxenite has been weathered apparent signs of bedding are brought out, which are often parallel to the bedding of the country rock. Thus at Bob's Lake mine in Frontenac county a rich-green pyroxenite occurs which exhibits this structure. For ten feet down from the surface this apparent bedding can be distinguished. It gradually grows fainter, until it disappears in the massive pyroxenite below. A similar phenomenon has been observed in the Emerald mine, Buckingham township, Ottawa county, Quebec, and at several other places. It can also be seen in the crystalline rocks on Newport island, opposite Tiverton, R.I. There, for a depth of from one to two feet, an apparent stratification can be seen, and the rock below gradually becomes more massive until it merges into the apparently homogeneous mass of the hill. The pyroxene occurs in several different forms. Sometimes it is massive, of a light or dark green color, and opaque or translucent; at other times it is granular and easily crumbled. Occasionally it occurs in a distinctly crystalline form, the crystals being in colors of different shades of dull green, gener-

Structure and occurrence of pyroxenite.

ally opaque or translucent, but sometimes, though rarely, almost transparent. The massive variety is the most common, and composes the greater part of the pyroxenites found in the phosphate districts.

Felspar and quartzite.

The associated felspar is generally a crystalline orthoclase, varying in color from white to pink and lilac ; occasionally, as in Denholm and Bowman townships, Ottawa county, Quebec, it occurs as a whitish-brown finely crystalline rock. The trap is of the dark, almost black, variety. Thin sections under a microscope show it to have a very variable composition—a network of striated blades of triclinic felspar, brownish augite, black opaque grains of magnetite, and commonly small quantities of green chloritic mineral. The quartzite is white, gray or blue. The blue variety often contains specks of felsite. These pyroxenes, felspars and quartzites are often mixed up in a perfect net-work, very similar to that seen at Marblehead, Mass., and at many places in the metamorphic rocks of Mount Desert island. Often whole hills are formed of these rocks, mixed in various proportions. The gneiss in some places has no distinct line of separation from the pyroxene, but seems to have been impregnated with some of it, forming for a few feet from the line of contact a more or less pyroxenic gneiss which is easily decayed and eroded by weathering. In the Ontario district, as mentioned before, the pyroxene is often replaced by hornblende. Thus at Bell's mine, in Frontenac county, little or no pyroxene is met with, and in its place large quantities of dark green hornblende occur. The apatite here is found in a rock consisting of green hornblende and white felspar which forms a ridge about one hundred yards wide, parallel to the strike of the country gneiss. To complete the list of rocks found in the apatite districts it is necessary to mention the large veins of crystalline calcite, which often contain serpentine and chrysotile. In the occurrence of these veins this Canadian apatite region is in marked contrast with that of Norway, where little calcareous matter is found.

Pyroxene replaced by hornblende.

Crystalline calcite

OCCURENCE IN VEINS AND DEPOSITS.

Occurrence of the apatite in veins, deposits and masses.

The apatite of Canada is found occurring in a great variety of ways. Prof. T. Sterry Hunt regards most of the workable deposits as veins, but he thinks there are also some deposits which occur in beds. He has discovered small masses of apatite marking the lines of stratification in the pyroxene. An instance of this was seen by the writer in an old pit in Buckingham township, Ottawa county, Quebec, where the apparent lines of stratification were marked by bands of apatite. Professor Hunt thinks that most of the deposits of apatite are concretionary vein-stones and have resulted from a hot water solution. He bases his belief upon several characteristic facts concerning Canada apatite, such as the rounded form of many of the apatite crystals, which he regards as due to the action of partial solution after decomposition and not of fusion as suggested by Dr. Emmons. Another argument is that one mineral in the vein is often found incrusting or containing fragments of another. Thus it is very common to find masses of crystalline calcite rounded into pebbles and buried in the centres of apatite crystals which are themselves worn and rounded, showing, as Dr. Hunt thinks, that the erosive action in the veins has taken place in at least two different epochs. The appearance in the veins of drusy cavities and the parallel deposition of the different minerals observed in many veins are also arguments for the theory of concretionary structure. Professor Dawson thinks that many of the deposits of the Ontario district are true beds

Fissure veins and pockets.

Prof. B. J. Harrington thinks that most of the phosphate deposits will come under the heading of fissure veins and pockets. He shows that many of the deposits cannot be beds because they cut across the strata of the country rock. Many of the veins are of considerable length. A very continuous vein composed of hornblende, calcite and apatite mixed in varying proportions and associated with sphene, zircon, mica, scapolite, etc., is found

in Renfrew county, Ontario. This vein, or what may be a series of similar and parallel veins, was traced by the writer for a distance of three miles, and it is said by the native prospectors to be traceable for 27 miles. It runs in a north 40° east direction, widening and contracting at intervals and varying from three to thirty feet in thickness. It can best be examined on Turner's island, in Clear lake, Renfrew county, Ontario, where several small openings have been made in it for the purpose of mining the rich apatite found there.* The island is three-quarters of a mile long and from one hundred feet to a quarter of a mile wide. The vein runs through its longer axis from one end to the other. The apatite occurs in crystals, sometimes in considerable quantities and composing the greater part of the vein matter, and at other times scattered sparingly through a mass of the crystalline minerals which accompany it. Apatite crystals of immense size have been found here. One prism is said to have weighed seven hundred pounds; a crystal of zircon almost a foot in diameter is also said to have been found in the same vein. A crystal of sphene from this locality in the Harvard mineral cabinet measures over a foot in length. The country rock on the island consists of a confused mass of felspar, coarse-grained, unstratified gneiss, and of a rock composed of felspar and hornblende. Small quantities of green pyroxene are also found. The vein is said to change into pure calcite at its extremities. It shows no signs, as far as seen, of banded or concretionary structure, but consists of a mass of crystallised minerals mixed in an apparently indiscriminate manner. Like most apatite deposits in Canada the vein has no sharp lines of division from the country rock, but gradually blends into it. The hornblende in the country rock becomes more perfectly crystalline and occurs in larger masses as the vein is approached, until finally when the vein is met the hornblende and the felspar crystallise out separately among the other minerals. "Such a blending of a vein with the walls," says Professor Dana, "is a natural result when its formation in a fissure takes place at a high temperature during the metamorphism or crystallisation of the containing rock." This blending of the country rock with the vein matter does not however always happen, as several cases were found where the apatite and associated minerals came into direct and sharp contact with the country rock. Thus on the land of the Sly brothers in Oso, Frontenac county, Ontario, there is a vein two feet wide in a gneissic rock. The boundary lines of the vein are sharply defined and white, red and transparent calcite is associated with grass-green hornblende and brown apatite in a mass apparently devoid of any banded structure. The vein dips at an angle of 85° north and strikes east and west. The country rock strikes north 20° east, and dips 40° to 45° east-southeast. A somewhat similar instance is seen in the same township at Boyd Smith's mine. Here were three veins apparently occupying joint planes and parallel to one another. The veins are composed principally of apatite and hornblende, and their genaral character is very similar to that of the last vein described. They strike north 15° west and dip at 10° northeast. The strike of the country gneiss is north 35° east, dip 60° southeast, so that it is evident that the deposits cannot be beds. They can be traced for 50 yards along the side of the hill.

The vein in Turner's island, Clear lake, Renfrew county.

Blending of vein matter and country rock.

Sharply defined veins.

BANDED STRUCTURE OF VEINS.

Some of the veins of apatite show a distinctly banded structure. On the land of James Foxton in Frontenac county, township of Loughborough, there is a series of gash-veins running in a general northwest and southeast direction. They are of all sizes from small ones not two inches thick to large ones three to six feet wide. The general character of all of them is the same.

Banded structure of veins on the Foxton property.

* The same or a similar vein is seen to great advantage on the land of Xavier Plaunt on the south side of Clear lake. It widens and contracts at intervals and runs in the same general direction as the Turner's island vein.

They occur in the country gneiss and occupy an almost vertical position. . . . The strike and width of nine of these veins were found to be:

North 11° west, six inches wide. Red apatite.
North 10° west, eighteen inches wide. Red apatite.
North 8° west, one to three feet wide. Red apatite.
North 20° west, one foot wide. Red apatite.
North 8° west, one foot wide. Red apatite.
North 35° west, six inches to one foot wide. Red apatite.
North 36° west, one foot wide. Red apatite.
North 45° west, one foot wide. Red apatite.
North 30° west, one foot wide. Red apatite.

The country gneiss is much contorted and strikes in various directions. It has an almost vertical dip. On the same properties there are also other veins running in various directions, but they are generally of small extent. In one place a vein was seen composed on one side of a band of apatite and on the other of a band of pyrites of iron containing masses of talc. Another instance of a banded vein occurs at Mud lake, Templeton township, Ottawa county, Quebec, where apatite, mica and pyroxene form the contents of the vein. But it is generally in the Ontario district that the banded structure is most often seen.

Character of veins in North Burgess.

In the township of North Burgess, Lanark county, Ontario, are many examples of phosphate-bearing veins, some of which can be traced for over half a mile, while others are short and amount to little more than pockets. In places the ground is literally cut up by a network of these veins varying from a few inches to over ten feet wide. Occasionally they are found widening into bunches almost twenty feet across. The veins often show a banded structure and consist of mica and pyroxenite on the outside and apatite in the centre. The outside bands of the veins are in some cases composed of a dark, almost black, talcose material. In other places the contents of the vein consist of apatite, mica, pyroxenite and white and flesh or salmon colored calcite, indiscriminately mixed and associated with small quantities of scapolite, zircon, sphene, talc, hornblende, specular iron ore, zeolites and other minerals. Veins also occur which are almost entirely composed of apatite crystals scattered in a matrix of granular quartzite. On the land of the Anglo-Canadian Phosphate company at Otty lake, North Burgess, where some of these veins have been opened to a depth of seventy to eighty feet, the mode of occurrence of the apatite is well seen. The prevailing country rock here is quartzite and garnetiferous gneiss. In some cases the line of division between the vein matter and the country rock is sharply drawn, while in others they gradually blend. Both of these phenomena, as well as the banded and the unbanded structure, are often seen in different parts of the same vein. The apatite occurs in bunches, sometimes connected by seams of the same mineral. From a single one of these bunches over a thousand tons have been taken.

Contents of phosphate-bearing veins.

The contents of the phosphate-bearing veins are often very variable at different points in the same vein, sometimes consisting mostly of apatite, scapolite, felspar and pyroxene, and at others being composed of crystalline limestone bearing crystals of the above minerals. Such a formation is seen on Henry Barr's land in Renfrew county. At the McKenzie mine in Bowman township, Ottawa county, Quebec, there is a vein in a hill of lilac-colored felspar and pyroxenite. One part of the vein is composed of massive apatite, holding crystals of pyroxene and scapolite, while another about fifty feet distant assumes a totally different character, being composed of a pink crystalline calcite bearing crystals of apatite. In some places the calcite has been worn away by the infiltration of water, and then the structure of the vein can be seen. The cavity is lined with crystals of scapolite and pyroxene which come next to the country rock, while the calcite bearing the crystals of apatite comes in the middle. This formation of drusy cavities in limestone leads is

very common, especially in the Ontario district. Often the calcareous matter has been washed away and crystals of apatite and their fragments are scattered over the bottom of the hollow. The formation of cavities seems especially apt to take place at the point of junction of the limestone and a harder mineral in the vein. Thus in the township of Loughborough, Frontenac county, Ontario, was seen a cavity where a mass of limestone in a vein came in contact with a mass of apatite-bearing pyroxenite. From this opening several hundred pounds of loose apatite crystals were taken.

OCCURRENCES IN IRREGULAR MASSES.

Though it will thus be seen that the apatite of Canada often occurs in well-defined veins, yet the largest deposits yet discovered occur in irregular masses in the pyroxenic and felspathic rocks. They seem to occur at some places in fissures and at others as simple segregations. As a general rule it may be said that the vein character is best developed in the Ontario district, while the segregation and pocket formations are more common in the Quebec district. . . . . It is also well known that phosphate of lime has, more than any other mineral, the property of forming into concretionary and segregated masses. Thus Professor Rogers found in the materials dredged in the Challenger expedition numerous phosphatic concretions scattered over many parts of the sea bottoms. Again in the phosphorite deposits of southwestern France and of Estremadura in Spain the concretionary form is one of the most common conditions of the phosphate, while in the phosphate region of South Carolina the nodular phosphates, especially those from Bull river, show sometimes a distinctly concretionary structure. At Crown Point, N.Y., phosphate of lime occurs in radiating and botryoidal masses forming the eupyrchroite of Emmons, and even in the guano beds of Peru concretionary nodules of phosphate of lime have been found.

Characteristics of occurrence in the Ontario and Quebec districts.

Concretionary forms of phosphate.

The pockets and fissures of apatite are of variable size, sometimes being only a fraction of an inch in diameter and sometimes consisting of immense bodies of massive or crystalline apatite measuring many feet in thickness. Such pockets are to be seen at the Emerald, Battle Lake, North Star, High Rock, Union and other mines on the Du Lièvre river. The apatite is generally not sharply divided from the pyroxenite, but gradually blends with it. The pockets show sometimes a banded structure, such as that of a cavity lined with pyroxene and the central part occupied by apatite. Occasional large boulders of country rock are found embedded in the apatite. Nearly all these pockets and fissure veins seem to take their distinctive characters from the including rocks. Thus where the including rock is pyroxenic, felspathic and calcareous, the crystals associated with the apatite are generally pyroxene, felspar and calcite, and where the country rock contains large amounts of hornblende, as at Bell's mine, Storrington, Frontenac county, at Barr's mine and on Turner's island in Clear lake, in Renfrew county, Ontario, there are always found large quantites of this mineral in the vein matter. The few veins however in which the lines of separation from the country rock are sharply drawn do not seem to be so dependent on the including rocks for their component minerals.

Pockets.

The depth to which the apatite extends is probably for all practical purposes unlimited. Some bunches of the mineral run out, but others are found at a greater or less distance below. The deepest openings in Canada are the North Star mine, township of Portland, county of Ottawa, Quebec, and the Battle Lake mine, township of Templeton of the same county. In September, 1886, they had reached the depths respectively of 350 feet and 210 feet. In both shafts large bunches of apatite were found, separated by pyroxenic or micaceous rocks containing smaller seams and bunches of that mineral.

Depth of apatite openings.

The apatite of Canada varies considerably in its physical character. Its color is green, red, brown, white, blue, purple or black. The black color is generally caused by the decomposition of the associated iron pyrites, and is seen in Ottawa and Frontenac counties. Apatite occurs in the crystalline, sub-crystalline, massive or granular form. The granular variety, known as "sugar apatite," is of a white or pale green color and looks like coarse sand, more or less coherent. It occurs principally at the Little Rapids mine, township of Portland, and McLaren's mines, township of Templeton, Ottawa county, Quebec, and is one of the purest forms of apatite mined. It is uncertain what could have caused the apatite to assume this granular condition. Some shipments from Ottawa county have analysed 88 per cent. of tribasic phosphate of lime. The apatite varies very much in its ability to withstand weathering. When it is free from pyrites it endures it very well and is almost as resistant to erosion as quartz, but when pyrite is present it quickly crumbles away. In some places where pyrites of iron and copper are found the apatite is brown and rusty for a depth of several feet.

Physical character of Canadian apatite.

MINERALS OF THE APATITE DISTRICTS.

Below is given a list of some of the more important minerals of the Canada apatite districts. The crystals often occur of immense size and in a state of great perfection. The zircons, sphenes, scapolites, pyroxenes, apatites and micas are especially fine, and probably are found nowhere else in such quantities and in such perfection:

Minerals of the apatite districts.

Apatite,	Tourmaline,	Wilsonite,
Calcite,	Titanite,	Talc (steatite),
Fluorspar,	Zircon,	Chlorite,
Pyroxene,	Orthoclase,	Prehnite,
Hornblende,	Quartz,	Chabasite,
Phlogopite,	Opal,	Galena,
Garnet,	Chalcedony,	Sphalerite,
Epidote,	Albite,	Molybdenite,
Idocrase,	Scapolite,	Graphite.

The apatite after being blasted out is put through the process of "cobbing," which consists of breaking it with a hammer from the adhering impurities. The highest grade which is shipped rarely averages over 85 per cent. tribasic phosphate of lime, and none of the mines ship much phosphate which does not average at least 70 per cent. Eighty per cent. apatite is considered first quality and sells for 11 to 12 pence a unit.*

Grades and prices of apatite of commerce.

MARKETS FOR CANADIAN APATITE.

The principal market for the Canada apatite is Europe. Great Britain and Germany consume over three-fourths of the total product, which in 1885 amounted to 23,908 tons. The market is unlimited and the output is yearly increasing, so that phosphate mining bids fair in a few years to be one of the most important industries of Canada. The annexed tables will show the output of the mines in past years, as well as the present markets. According to the Canadian Mining Review, January, 1886, the product for the past five years has been:

Markets.

Output of the mines.

1881	tons 15,601
1882	" 17,181
1883	" 17,840
1884	" 22,143
1885	" 23,908
Total for five years	" 96,673

*The expression 11 to 12 pence a unit is the commercial method of signifying the value of the apatite. It means 11 to 12 pence for each per cent. Thus 80 per cent. phosphate at 11 to 12 pence per unit would be worth $17.60 to $19.20 per ton.

Shipments to different ports (same authority):

		1884.	1885.
Liverpool	tons	8,557	9,563
London	"	4,389	7,683
Hamburg	"	2,970	3,524
Bristol	"	1,824	2,056
Glasgow	"	3,083	482
Barrow	"		350
Penarth Roads	"	100	100
Cardiff	"		65
Sharpness	"		45
Hull	"		40
Dublin	"	210	
Sunderland	"	60	
Bristol Channel	"	50	
United States	"	200	
Consumed in Canada	"	700	
Total	"	22,143	23,908
From Ontario district, 1885			1,500
From Quebec district, 1885			22,408

ORIGIN OF LAURENTIAN PHOSPHATES.

Theories of the origin of phosphates.

The origin or chemical history of these Laurentian phosphates has been a matter of considerable dispute. Dr. T. S. Hunt says that phosphates, like silica and iron oxide, were doubtless constituents of the primitive earth's crust, and that the production of apatite crystals in granite veins or in crystalline schists is a process as independent of life as the formation of crystals of quartz or of hematite. Prof. J. W. Dawson on the other hand thinks the Canada apatites are of animal origin, and bases his belief on the presence of eozoön and of graphite in the associated beds and of the flouride of lime in the apatite. He says: "The probability of the animal origin of the Laurentian apatite is perhaps further strengthened by the prevalence of animals with phosphatic crusts and skeletons in the primordial age, giving a presumption that in the still earlier Laurentian a similar preference for phosphatic matter may have existed, and perhaps may have extended to still lower forms of life, just as in more modern times the appropriation of phosphate of lime by the higher animals for their bones seems to have been accompanied by a diminution of its use in animals of lower grade."* Messrs. Brogger and Reusch in their description of the Norwegian apatites think that they are of purely eruptive origin.†

C.—ORES OF NICKEL.

Nickel on the Assumption river.

Small portions of nickel occur in several parts of the province and in other associations than those just mentioned. Among the Laurentian rocks in the eleventh concession of Dallieboust, on the land of Mr. Louis Levesque, there occurs on the bank of the Assumption river a quartz vein six or eight inches wide in gneiss. This vein holds a considerable amount of cubic iron pyrites which contains small quantities of nickel and cobalt. The amount of the mixed oxides of the two metals was found in two determinations to be only 0.54 and 0.56 per cent.

On Michipicoten island.

Some specimens furnished me by Mr. Charles Bonner (who aided me in several of the analyses) from a mine on Michipicoten island, lake Superior, contain two minerals which offer a more abundant source of nickel than the pyrites just mentioned. The first of these is associated with quartz, and is a massive mineral with an impalpable structure, a shining metallic lustre and a

*The reader should note the fact that since the admirable researches of Mobius it is doubtful whether eozoon be of organic origin.—N. S. S.

†Bulletin of the United States Geological Survey No. 46, pp. 23-41. By R. A. F. Penrose, jr., with an introduction by Prof. N. S. Shaler.

color varying from reddish-white to bronze-yellow; brittle, fracture uneven, sub-conchoidal, hardness 5.0, density 7.35 to 7.40. The mineral was at first supposed to be nickeline or arseniuret of nickel, but the results of several analyses show it to consist of a mixture of this species with an arseniuret of copper. The following are the results of four analyses of different fragments detached from the same mass:

	I.	II.	III.	IV.
Arsenic..........	37.36	44.67	.....	.....
Copper..........	44.70	30.81	27.60	10.28
Nickel...........	17.03	24.55	27.29	36.89
Silver...........	.....	.25	.21	.....
	99.09	100.28		

Composition of the ore.

It will be apparent from the following calculations that these different specimens are mixtures of nickeline $Ni^2 As$, and domeykite $Cu^6 As$, the former containing 44.1 of nickel and 55.9 of arsenic and the latter 71.7 of copper and 28.3 of arsenic. For the first analysis 44.70 parts of copper require 17.67 of arsenic to form 68.37 of domeykite and 17.03 of nickel unite with 21.57 of arsenic to form 38.60 of nickeline, requiring in all 39.42 parts of arsenic, while the analysis gives 37.36 parts, besides a deficiency of 0.91 which probably corresponds to a loss of arsenic. For the fourth analysis we have only 10.28 of copper, requiring 4.05 of arsenic to form 14.33 of domeykite and 36.89 of nickel which demand 46.74 of arsenic, giving 83.63 of nickeline and amounting to 97.96 for 100 of the mineral. The nickel contains traces of cobalt. It is desirable that this locality should be further examined, for an ore so rich in nickel is very valuable. The arseniuret of copper, which evidently predominates in some portions of the mass, is as yet a very rare species.

Nickel ore as a gangue of native copper and silver.

Another ore of nickel, said to be from the same mine as the preceding, occurs as the gangue of native copper and native silver which are disseminated through it in grains. The mineral is amphorus, color greenish-yellow to apple-green, lustre waxy, sub-translucent, fracture conchoidal, very soft, polishes under the nail and falls to pieces when immersed in water. It is decomposed in acids with separation of pulverulent silica. The analysis of this material shows the presence of silica, alumina, oxides of nickel and iron, lime, magnesia and water. It yields moreover traces of copper and cobalt, but no arsenic. Two portions of the mineral carefully freed from the disseminated metals gave the following results. The specimen in the first analysis had been dried at 212° F., the other at a higher temperature and had lost a portion of water.

	I.	II.
Silica..............................	33.60	35.80
Alumina...........................	8.40	} 11.00
Protoxide of iron	2.25	
Oxide of nickel..................	30.40	33.20
Lime	4.09	3.81
Magnesia	3.55	3.37
Water	17.10	12.20
	99.39	99.38

Another fragment containing the native metals in small grains gave me silver 2.55, copper 18.51 and oxide of nickel 20.85 per cent. It is said that

a large quantity of this valuable ore was thrown away at the mine, being stamped and washed for the purpose of extracting the copper and silver.

This substance can hardly be supposed to be homogeneous in its composition, being not improbably a result of the alteration of some other ores. It resembles closely in its character the composition of the nickel-gymnite of Genth which gave to that chemist silica 35.36, oxide of nickel 30.64, oxide of iron 0.24, magnesia 14.60, lime 0.26 and water 19.09, but neither of these hydrated nickel ores are crystalline, and they are perhaps rather to be regarded as mechanical mixtures than distinct mineral specimens.*

D.—ELGIN SILVER MINE.

Mr. John Dickie, manager of the Elgin Silver Mine Co., writes of that company's location as follows: "The Elgin Silver Mining Co.'s location, containing 325 acres, is situated at the head of Jackfish bay, on the north shore of lake Superior. The position of the mine is about the middle of the lot and about half a mile from the navigable waters of the bay. There is abundance of serviceable timber, consisting of birch, spruce, poplar, balsam and tamarac from one to two feet in diameter on the location. Two permanent streams, one on each side of the bluff on which the mine is situated, flow through the location. The one on the west side drains five small lakes on the mountains above. On this stream, about 180 yards from the mouth of the mine, is a waterfall about 25 feet in perpendicular height, which would give a sufficient power to drive all the machinery necessary. From the edge of the bay to within 100 yards of the mine is almost level, the rise not being more than 10 feet. The C.P.R. station is six miles from the mine, although the track at one place is only about three miles distant. The lode has been located, and on different assays the ore has proved rich in both silver and gold, the yields being from $120 to $700 of silver and from $60 to $100 of gold to the ton. The vein has increased in extent and richness the farther it has been pierced. The company's charter calls for 1,000 shares at $50 each. Of this amount 200 shares were given to the original owners of the location. Other 200 shares have been sold and the money spent in exploring the mine. All experts who have seen the mine or specimens of the ore have expressed themselves thoroughly satisfied as to the great apparent value of the property.

The location.

Water power to drive machinery.

Character of the ore.

E.—DISPUTED TITLE.

The title to lands in the section of country west of Port Arthur was for a long time in dispute between the governments of the Dominion and Ontario, before and subsequent to the settlement of the boundaries of Ontario towards the west and north. After the decision of the Judicial Committee of the Privy Council establishing the western boundary along a line drawn due north from the north-west angle of the Lake-of-the-Woods, a claim was set up on behalf of the Dominion government as rightful owner of all land from lake Superior to Red river which had been occupied by Indian tribes in Ontario territory, together with its timber and minerals. "There is not one stick of timber, one acre of land or one lump of lead, iron or gold that does not belong to the Dominion or to the people who purchased from the Dominion government." So said the First Minister of that government, and the dispute is alleged to have interfered with the mineral development of the

Title to lands in northwestern Ontario.

* Dr. T. Sterry Hunt in the report of the Geological Survey for 1853-6 pp. 388-90.

country, especially in the region of the Lake-of-the-Woods, as the following statements of witnesses examined by the Commissioners show:

Capitalists afraid to invest till the title is settled.

William Murdoch—I am interested in gold claims on Lake-of-the-Woods. If the question of title were settled in the Lake-of-the-Woods district there would be a rush of capital into it. Americans who have been there express themselves well satisfied, but are afraid to invest anything till the dispute between the governments is settled.

A serious cause of slow progress.

John K. Wright—One serious cause of the slow progress of development in this district is the dispute as to title between the Ontario and the Dominion governments. I know that many capitalists have come here from St. Louis, Chicago, Minneapolis and other places for the purpose of investing and have gone away disgusted because a satisfactory title could not be obtained, although they were well pleased with the outlook of the country.

The disputed title has killed mining development.

Alex. Matheson—The affairs of the Winnipeg Consolidated company have never been wound up and the crown lands department refuses to issue a patent until the dispute as to the title is settled between the two governments. The parties who own a majority of the stock are desirous of buying out the smaller stockholders and securing the title in themselves. The disputed title has killed mining development in the country; in fact it has interfered with anything at all being done on the lake. American or Canadian capitalists will not invest as long as the question of title is unsettled. The hope of an early settlement has spurred on prospectors last year and this year. I think more locations have been taken up this year than in any year since I came to the country.

The Winnipeg Consolidated company's location.

A lumbering company's claim.

George Mitchell—So far nothing has so much hindered development here as the disputed question of title. Col. Robbins of Eureka, Nevada, examined the Winnipeg Consolidated with a view to purchase when the shaft was at a depth of 30 or 40 feet, and was so satisfied with its show that he offered to take the property on the condition of a good title being given. He has been in communication with myself and others frequently since, and is still anxious to procure a mining location here. This is one instance out of many. The Keewaydin lumbering company's lease also stops development to a very considerable extent, the company claiming absolute control of the land covered by the lease, and the manager treats all prospectors and miners on the company's limits as trespassers.

Locations in dispute.

Dr. Henson—A government commissioner should be appointed to settle all matters of title between contending claimants as soon as the question at issue between the Ontario and Dominion governments is decided. There are a large number of locations in dispute between prospectors and other parties, and means should be found for speedy settlement of them. The Sultana island gold location was practically sold a few weeks ago to a syndicate of American capitalists, but we were unable to produce title. An English company is also anxious to get hold of it, and negotiations are now going on. There would be no difficulty in getting capitalists to invest here if the question of title was settled. When that question is settled the disputes of rival claimants must be arranged, and especially those arising out of the pretensions of the Keewaydin lumbering company, which asserts a right to all the islands in the lake. A little development work has been done on the Keewaydin and Heenan locations, but it has been stopped by the lumbering company.

Imperfect titles hindering development.

Arthur Harvey—I have made no improvements or developments on gold property in which I am interested in the Rat Portage district because the titles are imperfect owing to the dispute between the two governments.

The question of title finally decided by the Judicial Committee of the Privy Council.

The matter in dispute was finally decided upon an appeal heard before the Judicial Committee of the Privy Council in a case between the government of Ontario and the St. Catharines Milling and Lumbering Co., the company claiming the right to cut timber upon a limit held under a lease granted by the Dominion government. Judgment was in favor of the contention of the Ontario government, thus establishing its right of possession to all land, timber and minerals constituting the public domain.

F.—DETERMINATION OF MINERALS.

The following is taken, with some changes and omissions, from Copp's Manual for the use of Prospectors, and furnishes information which may be found useful to men of that class:

CHEMICAL ELEMENTS.

Ninety-nine hundredths of the earth's crust is composed of less than sixteen elements and their chemical and physical compounds. An element is a primary substance. It cannot be made by uniting different things, nor can it be separated into anything unlike itself. A compound is made up of two or more elements. A chemical compound generally is one wherein the things composing it are so changed as not to be recognised by one or more of the senses of sight, taste, touch or smell. A physical compound generally is one wherein the substances composing it are unchanged, or so slightly changed as to be observed without difficulty. To illustrate, water is the chemical union of oxygen and hydrogen, invisible gases. Common salt is a white substance, composed chemically of a green gas (chlorine) and a silvery metal (sodium). On the other hand, if salt and iron filings be placed together and thoroughly mixed, the eye can easily tell the iron from the salt. If sugar be dissolved in a cup of water the water looks unchanged, and the sense of taste can detect the sugar. The first two are chemical compounds, the last two physical.

Elements and compounds.

ELEMENTARY SUBSTANCES.

The number of elementary substances at present known to enter into the composition of the crust and atmosphere of the earth is 64. Of these oxygen is estimated to constitute 50 per cent. of the earth's crust, silicon 25, aluminium 10, calcium 4.5, magnesium 3.5, sodium 2, potassium 1.6, carbon, iron, sulphur and chlorine 2.4, and all other bodies 1 per cent.

Very few elements are found pure in the earth; nearly all occur as compounds. Oxygen is the great compounder. Oxygen one-fifth mixed with nitrogen four-fifths makes the air about us. It chemically unites with every known element except fluorine, forms one-half the earth's crust, eight-ninths of water, four-fifths of vegetables (by weight) and three-fourths of animals (by weight.)

Oxygen united with the non-metallic elements forms acids,† viz. sulphuric acid, nitric acid. With the other elements it forms bases. Acids and bases united form most of the minerals. Chemical composition is indicated by the use of *ide* and *ate*. *Ide* indicates the union of two elements. *Ate* shows at least three elements, one of which is oxygen.

Chemical unions.

Sodium chloride (salt) is a union of sodium and chlorine. Silver sulphide, sulphur and silver. Copper oxide, copper and oxygen. Iron sulphate, (green vitriol) shows that oxygen is united with iron and sulphur. Calcium carbonate (limestone) is composed of calcium, carbon and oxygen.

Characteristics of the principal elements.

Hydrogen forms one-ninth part of water. This gas is the lightest of known substances. It burns freely with a bluish flame.

Nitrogen makes 80 per cent. of the atmosphere, yet by itself destroys animal life.

Chlorine is $2\frac{1}{2}$ times as heavy as air, and united with sodium forms common salt. It is a useful element in other compounds.

Fluorine forms with calcium fluorspar, and with hydrogen hydrofluoric (fluo-hydric) acid, used to etch on glass.

Silicon combined with oxygen forms silica or quartz.

Carbon, pure, is a solid, and forms the principal part of coal, plumbago and bitumen. Charcoal is almost pure carbon. Diamond is pure carbon crystallised. United with oxygen it forms carbonic acid, and this acid in combination forms a class of minerals called carbonates. Limestone is carbonate of lime.

* Acids and bases require water to complete them.

Sulphur is a yellow brittle solid. It is most abundant in volcanic regions. Combined with metals it forms a class of minerals called sulphurets or sulphides.

Phosphorus is a white, waxy substance. It is quite abundant in nature in combinations. With lime and oxygen it forms the phosphate of lime.

Aluminium is found only in compounds. With oxygen it forms alumina, of which the gems ruby and sapphire are pure specimens. It largely constitutes clay and felspar.

Potassium is one of the lightest of metals. With oxygen it makes potassa or potash.

Sodium with oxygen forms soda.

Calcium with oxygen makes lime.

Magnesium with oxygen forms magnesia, an abundant substance in the composition of many rocks.

The other elements are either well known or would require too much space for description.

MINERAL AND ROCK DEFINED.

Scientific distinctions.

A mineral is an element or two or more elements chemically united as found in nature. Water is a mineral. A rock generally lacks definite chemical composition, and usually consists of two or more minerals physically united or mixed, and found in nature. If a man makes a hard substance by mixing sand and cement it is not a rock or a mineral, because not found in nature. Scientists usually distinguish minerals from rocks in their names. The names of minerals usually end in *ite*, the names of rocks in *yte*. Halite is the mineral common salt. Trachyte is a common rock in mining regions. Dioryte, phonolyte, doleryte, are rocks. The rock well known as granite will probably maintain its old spelling. There are about 700 well known minerals; of these 200 are *ides*, 200 are silicates and 300 are other *ates*—sulphates, etc.

AIDS IN STUDYING MINERALS.

The physical properties of minerals will aid in their determination. Lustre, color, transparency, malleability, sectility, brittleness, elasticity, taste and odor will receive attention.

Hardness.

The scale of hardness is talc 1, rock salt 2, calcspar 3, fluorspar 4, apatite 5, felspar 6, quartz 7, topaz 8, sapphire 9, diamond 10. To illustrate, a mineral that will scratch apatite and is scratched by felspar is said to have a hardness between 5 and 6. A simpler scale is suggested, thumb-nail, knife and quartz crystal. The thumb-nail will scratch 1, 2 and 3. A knife will cut from 1 to 6. In fact many miners trust entirely to their knives to settle the question of hardness. Minerals that will scratch quartz crystals are rare.

Specific gravity.

Specific gravity refers to comparison of weight. Pure water is taken as the standard. The mineral is attached by a slender thread beneath one side of a balance, or under a spring scale, and its weight found. Next let the mineral hang in a glass of water, and as it thus hangs find again its weight. It will be less than before. Subtract the weight in water from the weight in the air and divide this difference into the weight in air. For example, suppose a piece of iron in air weighs 460 grains; in water 401.16 grains. $460 - 401.16 = 58.84$, difference. 460 divided by 58.84 equals 7.8, the specific gravity of iron.

Using the blowpipe.

To use the blowpipe, practice is necessary to secure a continuous stream of air from the mouth. Pieces of charcoal, small spirit lamp, bottle of alcohol and some borax and soda, with some copper and iron wire, make an outfit. If the prospector cannot carry all these things he may often secure satisfactory results by using with the blowpipe a piece of burning wood from his cooking-fire. In using the blowpipe it is important to remember that a trial of fusibility with the forceps, if not at once producing fusion, should be made

on a piece of the mineral not larger than the fourth of an ordinary pin-head, and it should be either oblong and slender, or thin, and be made to project considerably beyond the points of the forceps, lest the forceps carry off the heat, and cause a failure where there ought to be success.

Further, it should be borne in mind that in using charcoal a white coating is always a consequence of burning it, since the ash from its own combustion is white.

Crystallography

Minerals are mostly crystallised, and a knowledge of crystals is an important aid to a prospector. The subject is too complex and extensive for the scope of this work.

Simple tests.

An outfit for making the simple tests suggested below may consist of three small bottles with glass stoppers, one of nitric acid, one of hydrochloric acid and one of sulphuric acid, half a dozen test tubes and some glass tubing, pair of forceps, or piece of tin with a hole in it, in addition to the blowpipe outfit described above.

Carbonates—Nitric or hydrochloric acid poured on powdered minerals containing carbonic acid will cause a brisk boiling or effervescence.

Gelatising Silica—Some silicates when powdered and treated with hydrochloric acid deposit the silica as jelly. Burning before treatment is advised in some cases.

Decomposing by Acids—Some minerals after being finely powdered and boiled with strong acid will deposit silica or sulphur or other substances on the glass above or as a sediment at the bottom.

Odor of Fumes—Before the blowpipe sulphur, arsenic, selenium and phosphorus compounds give off their peculiar odors. Antimony fumes are dense, white and without odor.

Fusibility—The scale of fusibility is from one to five. A mineral that will melt in a candle flame is 1; that cannot be fused, 5.

Color of Flame—When a mineral contains sodium it will burn with a deep yellow flame. When soda is absent potash will give a pale violet flame, lime a pale reddish-yellow, lithium deep purple-red, strontium a bright red, copper emerald green, phosphates bluish-green, boron yellowish-green, copper chloride azure blue.

Zinc—This metal when heated covers the charcoal with zinc oxide, which is yellow while hot and white on cooling.

Lead—When the mineral is treated with soda on charcoal in the oxidising flame the yellow oxide coats the charcoal.

Copper—The flame is mostly bright green. With borax a red or green bead is formed.

Mercury—Heated in a closed tube with soda, mercury is deposited and covers the inside of the tube.

Silver—Argentiferous galena is tested on bone ashes and subjected to the oxidising flame. The lead sinks into the bone and leaves a brilliant globule of silver.

Chlorides—If a bead of borax be saturated with copper oxide and then dipped into the powder of a substance which is to be tested for chlorine, a chloride of copper is formed which imparts an azure-blue color to the flame if any chlorine is present.

Phosphates—These give a dirty green color to the blowpipe flame. The color is more distinct if the substance is first moistened with sulphuric acid.

Carbonates of Silver and Lead—To assay carbonate of silver and lead, take the mineral or quartz, pulverise it, put it in a crucible or common clay pipe; put in as much common salt as mineral; let it come to a boil. When it cools the silver and lead will be in the bottom, silver the lowest. To separate the lead from the silver, put it in a bone dust cup and melt; the lead will absorb into the cup, leaving the silver and gold. To separate the latter, boil it in nitric acid and this will leave the gold.

Trials of specimens.

Quartz occurs of nearly every color, and of various degrees of glassy lustre to a dull stone without the slightest glistening. The common grayish cobble-stones of the fields are usually quartz, and others are dull red and brown; from these there are gradual transitions to the pellucid quartz crystal that looks like the best of glass. Sandstones and freestones are often wholly quartz, and the seashore sands are mostly of the same material.

Let the first trial of specimens obtained be made with a file or the point of a knife, or some other means of trying the hardness; if the file makes no impression, there is reason to suspect the mineral is quartz; and if, on breaking it, no regular structure or cleavage plane is observed, but it breaks in all directions with a similar surface and a more or less vitreous lustre, the probability is much strengthened that this conclusion is correct. The blowpipe may next be used, and if there is no fusion produced by it in a careful trial there can be little doubt that the specimen is in fact quartz.

Calcite (calcium carbonate), including limestone, is another very common species. If the mineral is rather easily impressible with a file, it may be of this species; if it effervesces freely when placed in a test-tube containing dilute hydrochloric acid, and is finally dissolved, the probability of its being carbonate of lime is increased. If the blowpipe produces no trace of fusion, but a brilliant light from the fragment before it, but little doubt remains on this point. Crystalline fragments of calcite break with three equal oblique cleavages.

GOLD.

Gold, specific gravity 19.3, is a brilliant, solid, lustrous heavy metal, of a lordly appearance and magnificent yellow—golden yellow—color. There is but one color to gold, and all the variations from that color simply prove the presence of alloys and the impurity of the gold, or whatever goes by that name. It is a saying among the miners that a "great many other things are mistaken for gold, but gold is never mistaken for anything else." It is about as difficult to say certainly where gold comes from as where it goes to, as at both ends of its course it is in the smallest possible particles.

Its occurrence with pyrites.

About the bottom fact now known about gold is that all *original* iron pyrites of small grain texture contain gold to a greater or less extent. Of course this does not cover such secondary large crystal pyrites as those found in the coal measures and elsewhere, but only the pyrites in veins or comparatively unaltered pyritous deposits derived from veins. It is not yet known whether the gold in these pyrites is in chemical combination with sulphur as a sulphide of gold, or whether each minute particle of gold is simply covered with a coating of sulphide of iron, or whether the pyrites is a double sulphide of iron, or whether the particles of gold are in the metallic state, but alloyed with silver or other metal which combines more readily with sulphur than the gold does, and consequently forms a coat of sulphide of silver, etc., over the gold. The particles of gold are so minute, and the combinations, dissociations and re-combinations follow so rapidly during the splitting up of these pyrites, that the finest instruments and tests known to chemistry have as yet been unable to settle this part of the question to the satisfaction of all concerned.

Its occurrence in quartz veins.

Gold is found not only in the sulphide veins, but also in the crystalline or quartz and composite veins formed during the dislocation and upheaval of rocks. Quartz that looks like coarse-grained white sugar is a good sign, but clear rock crystal quartz, or quartz with a glassy vitreous lustre, with no grains in its texture, never holds gold. The granular quartz in veins, badly stained with iron rust, and full of little sharp-cornered cells with iron dust in them, is the best prospect, and when this quartz is in streaks or sheets standing on edge, and intercalated between sheets of all sorts of yellow and brown

minerals, and some sulphides of iron and copper, all filling up a vein which has masses of brown spongy iron ore or "gossan" scattered over the surface at its outcrop, then the prospect requires immediate attention. The mass of one of these veins may yield from $20 to $50 per ton by the usual rough processes, and yet not a particle of gold can be seen in the rock with the naked eye, and a powerful glass reveals but few specks.

These sulphide veins are the original home of the gold so far as we know, and their location is nearly always in the talcose slates of the Huronian formation, although in rare cases they can be traced upward into the bottoms of the lower Silurian or whatever rock immediately overlies the slate. Many veins show soft, decomposed and earthy rock and mineral filling the fissure for some hundreds of feet down from the outcrop to the water level of the country, and so far things go on comfortably; but when the sulphides are hard and bright and sharp cornered, and the water gets troublesome, it is more than time for the mining engineer to come with his desulphurising furnaces and scientific processes.

Original home of the gold.

Frequently whole beds of these talcose slates will be found pierced in many directions by many systems of veins or seams of all sizes, from a mere ribbon set on edge up to many feet in thickness; and where many thin veins are found the whole mass of rock is crushed, instead of attempting to mine out any one vein. This plan of crushing the whole mass is also used where the slate beds are filled with small grains of quartz and pyrite, or little cells where the pyrite has been oxidised, this slate being simply an old bed of sand, mud, etc., which has been washed down from some earlier rock with a pyrite vein in it. Where such a washed down bed of debris has existed long enough to have become compacted into a rock, it is a gold bearing bed of rock; but where the washing down process took place in recent times it is a gold bearing bed of mud, clay, sand, gravel or anything else, and it is a wet or dry "diggings" according to its location above or below water level. Whole hills of sand, gravel and clay may have gold distributed throughout their entire mass, or the gold may be in a "streak" or "lead" running through the hill at a certain height or on the bed rock.

Veins in Huronian talcose slates.

Secondary deposits.

Gold occurs in all these secondary deposits, not as in veins, in particles too fine to be detected, but as "wash" gold in grains from dust size up to the nuggets of many pounds weight. That this wash gold is derived from the vein gold is a fact acknowledged by all; but how the fine particles became agglomerated into nuggets or grains is an unsolved question, although thinkers and observers in great number have advanced endless theories about electricity, galvanism, precipation, cold welding, etc., but so far all the facts are not accounted for.

Theories on the history of gold.

Another obscure point in the history of gold is that in the quartz veins, free from sulphur, the gold is sometimes found in grains, nuggets, sheets or strings, looking as though it had been melted, leading to the conclusion that these quartz veins have been reduced by heat from very silicious sulphide veins, or that the quartz has come up from below in a melted state, and after passing through sulphides and driving off the sulphur has brought the gold up with it. Something of this kind is indicated by the fact that auriferous quartz contains no water of crystallisation, differing in this respect from the crystalline varieties with shining surfaces or transparent bodies. Free gold quartz veins, when washed down, yield gravel diggings containing coarser wash gold than gravels derived from sulphide veins.

Gold in the sulphides and clays may be so fine as to be really invisible except under a powerful microscope; and small as the particles are they are nearly always flat and just fitted to float away with any current of water that will carry off the mud. The best plan with fine stuff, it is said, is to let water alone and pulverise everything to the finest possible condition, with mercury

Separation of fine gold by mercury treatment.

in the mill and no water to get between it and the gold, then blow this powdered rock or clay and the amalgam all together through a long, horizontal revolving pipe, with a bright pool of mercury in the bottom and rings or dams at short intervals to deflect the current of air and dust, etc., to impinge upon the constantly fresh, rolling surface of the mercury, which captures the drifting particles of amalgam while the lighter rock and iron dust float on with the air-current. An air-current of two *feet* per second will not float dust and scale gold that a water-current of two *inches* per second would carry off with ease, and the air-current thus enables us to work with very much more finely pulverised material than the water-current. One of the great troubles with all water processes is the great waste of gold in the "slimes," these being simply those portions of the vein-stones that have been pulverised too fine for the rough processes inseparable from the use of water, but which slimes are just in the most convenient size of grain for the gentle air-current to blow away, leaving the gold behind in the mercury pipe. It must be remembered that the gold in the sulphides is in the finest possible condition for gold, and the sulphides containing it must be pulverised to at least the fineness of the gold, or *all* the gold is not freed from its imprisonment; and it is further to be remarked that the gold being soft and tough can be flattened into scales by further trituration, but cannot be broken into smaller particles, although the vein-stone can go on being pulverised finer and still finer until it is so much lighter and smaller than the gold as to be floated out by an air-current that will not even lift the scales in spite of the fact that the pulverised rock is in globules or cubes. Another point is that the more the particles of gold are flattened out into scales by dry crushing in contact with mercury, just so much the greater (and the brighter) is the gold surface for the mercury to lay hold of it and hold it down by adding the weight of the mercury to that of the gold while the rock-dust blows away. Just the opposite of this is the case with the water process, where the more the gold is flattened and brightened the more easily it is floated over the surface of the mercury, by reason not only of the water getting between them, but also of the film of air which isolates the gold in the water by floating it and by keeping a membrane of water around the air again. It is well to remember also that air can always be had even in the most inaccessible mountain ledges, while water is not always easily obtained.

Waste of gold in the slimes.

A good test is to pulverise the vein-stone and dissolve it in aqua regia (nitric and hydrochloric acids), then pour in a solution of copperas (sulphate of iron), which will percipitate the gold (if there is any) in a brown powder to the bottom of the glass; rub this powder with a knife and it reveals its true gold color. The relative weight of the gold thus obtained, when compared with the weight of the original vein-stone, will give the rate of yield if it was a fair average sample.

A test for gold.

Mica and the two sulphides of iron and copper are more often mistaken for gold than any other substance; but by remembering that mica is in bunches of sheets, that iron pyrite is hard and angular and brittle, that copper pyrite is soft and brittle and cuts into powder, but that gold is not in bunches of sheets, is not sharp cornered nor brittle and hammers out flat, can be cut into threads without crumbling, mistakes will be avoided, especially when note is taken of the great weight of gold when compared with the substances mentioned.

Common mistakes which may be avoided.

SILVER.

Silver, specific gravity 10.53, is an excessively brilliant pure white metal, of great malleability and ductility. It is harder than gold but softer than copper, and can be cut with a knife when pure; but a very little alloy hardens it disproportionately. It is found naturally in the metallic state (but never

Its characteristics.

entirely pure), and also in combination with other substances forming ores. The metallic silver, as found native, generally has a slightly darkened and dull looking surface, but reveals its true color when cut or scratched.

Silver glance, or sulphide of silver, gravity 7.0, contains 86 per cent. silver and 14 of sulphur. It is dark gray to blackish in color, dull externally, but showing a vitreous metallic lustre when cut, and can be cut as easily as lead and is slightly malleable—gives off a sulphur smell when heated. This is the great ore of silver and can be found in nearly all the formations except the coal rocks. It is rarely pure and never forms the entire metallic contents of a vein. Lead veins nearly always contain this ore mixed with the galena. Galena that is small grained is always argentiferous, but the large grained galena rarely has it in paying quantities. The sulphides of zinc and antimony and frequently copper will bear testing for silver glance. The limestones of the Silurians and Devonians are the most likely places to find silver-bearing lead ores, and next after these the slate rocks of the upper primaries. Sulphide of silver.

Red silver, gravity 6 to 6.5, when dark red in color, contains 60 per cent. silver, 20 of antimony, 12 of sulphur and 8 of oxygen, is almost opaque, has a metallic lustre and is usually found in crystals. When it is a clear transparent red color, it is a double sulphide of silver and arsenic and contains 65 per cent. of silver. Red silver.

Horn silver, gravity 5.5, is chloride of silver, contains 75 per cent. silver and 25 of chlorine. It looks like pearly gray putty or wax, sometimes slightly bluish. The exposed portions on the outcrops of veins look like brown or black cement. It is soft, easily cut and can be hammered out slightly. Chloride of silver.

Silver amalgam, gravity 14, is much heavier than pure silver, as it contains 64 per cent. mercury to 36 of silver. It has a very bright silver-white color, is very soft and can be cut with a knife. It is really not an *ore* of either silver or mercury, but simply an alloy or mechanical combination of two native metals. It is one of the principal sources of silver in South America, but has not yet been extensively found in North America. Alloy of silver and mercury.

All silver ores are to be looked for in any kind of veins in any of the rocks below the coal measures. All sulphide veins of copper, antimony, zinc or lead need testing for silver, as they are nearly always found associated. The silver may not be in paying quantities, but that can only be asserted positively after testing. All galena that is fine grained and not plainly cubical in texture may be confidently examined for silver. Rocks in which silver occurs.

To test mineral for silver, dissolve a piece in nitric acid, pour in strong salt water and if the resulting white powder should turn black on exposure to sunlight it contains silver. A simple test.

IRON.

Iron, specific gravity 7.78, is a silver-white fibrous and ductile metal, and the most valuable to man of all earth's mineral productions except coal. It is the strongest of all metals, as well as the most universally diffused, some one or other of its ores being found in all the formations. It is susceptible of very high polish, but its affinity for oxygen is so great that it tarnishes very easily and is never found entirely pure in a state of nature. Some nearly pure bits and small masses have been found in many ore-veins, but always show traces of having been reduced from the ores by heat or precipitation from solutions. Masses of nearly pure iron occurring as shooting stars or meteors are frequently found where they have fallen, but are preserved from further oxidation by a glazed or vitrified surface caused by the heat from friction with our atmosphere during their rapid passage through it. The iron supply of the world is entirely drawn from the natural ores of this metal, the few specimens of native metallic iron being useful only as cabinet specimens. Qualities of the metal.

Magnetic ore. Magnetite, or black oxide of iron, loadstone, magnetic ore, etc., gravity 5.1, is a proto-sesqui-oxide of iron, in the proportion of 72 per cent. of iron and 28 per cent. of oxygen when the mineral is unmixed with impurities. It is black in color; has metallic lustre: its powder is black and it occurs crystalline and granular, sometimes earthy and compact, but crumbles easily into coarse black sand and is attracted by the magnet. It is found principally in veins and beds throughout the primary rocks and sometimes in the sandstones, etc., lying immediately upon the primaries.

Specular ore. Gray oxide, gravity 5.0, is the sesqui-oxide and contains 70 per cent. iron to 20 of oxygen. This ore is the specular hematite, is of steel-gray color, of high metallic lustre and its powder is red. It is brittle and crystalline and frequently slaty in structure, and is found principally in beds in the primary rocks or those immediately overlying them, and the black oxide is nearly always in company with it, being of similar early origin.

Hematite ore. Red oxide, gravity 5.0, is also the sesqui-oxide and contains 70 per cent. of iron to 30 of oxygen when pure. This ore is properly called hematite (meaning blood-red ore), inasmuch as it is red both in mass and in powder. It is of secondary origin, being derived from the foregoing oxide by being powdered, washed off and re-deposited in secondary beds which retain the red color of the powder from which they were built. This ore is sometimes deposited as regular beds or strata of rock and for long distances—frequently hundreds of miles—it holds its position as a member of a formation.

Limonite ore. Brown oxide, gravity 4.0, contains 60 per cent. iron, 26 oxygen and 14 of water. Its proper name is limonite and it is frequently called brown hematite, apparently because it is *not* blood colored either in mass or in powder. It is a hydrated sesqui-oxide of iron and appears to be derived from the foregoing oxides by being carried off and re-deposited from a *solution*, whereby it enclosed its water of hydration, while the red oxide was simply carried off in *suspension* as powder. The brown oxide is brown, yellow or purplish brown or black, but its powder is always yellow. It is generally compact and frequently massive, and like the dry oxides it often forms great cliff formations in the structure of hills and mountains. This ore is rarely gritty, but sometimes granular, and a very pure and valuable variety looks just like a black iron sponge, having a vitreous lustre when broken. Sometimes it occurs in hollow balls, with the interior surface covered with black velvety crystals; and when these balls are fibrous in texture, the fibres radiating from the centre to the circumference, it is called needle ore. Sometimes it is in masses in wet lands, either as concretions or as masses of hard brown earth, loosely packed when it is bog ore. It puts on more different appearances than any other ore, and owing to its deposit from solution it has been carried everywhere that water can reach and may be looked for in all the formations. In one shape or another it is the most valuable of American iron ores.

Carbonate of iron. Carbonate of iron, gravity 3.5 to 4.0, sometimes called siderite, chalybite, sparry or spathic iron, according to circumstances, is of many varieties, but the definite mineral contains 42 per cent. of iron, 20 oxygen and 38 of carbonic acid and other impurities. It is never found naturally pure, but always mixed with sand, lime, clay, etc., and is a clay ironstone, properly speaking, in America. It occurs in the secondary and later formations, and is most abundant in the coal measures, but the nodular ores of the tertiary clays, such as those from which the best Baltimore iron is made, are carbonates. It may be of any color or shape from white, gray or yellowish masses to brownish purple nodules, looking like fragments of exploded shells, or from flattened balls to the full black band ores of the coal measures of western Kentucky or of England. It is also found in beds intercalated between other rocks, sometimes in a continuous massive formation looking like gray or yellowish limestone, but more frequently the ledge is a mass of flattened

balls or kidneys of large size, mixed with smaller balls and grains of the same ore, with a lime cement, and the outcrop of such beds or ledges is generally weathered into brown, spongy-looking masses of limonite. It is not one of the most valuable of American ores, where we have so much more of the richer oxides, but the black band and the clay band carbonates of England have heretofore produced more than half the iron supply of the world. In America we use the carbonates chiefly for mixing and tempering the richer oxides.

Iron pyrites or fool's gold, gravity 5.0, is a bisulphide of iron and contains 54 per cent. of sulphur to 46 per cent. of iron. The rule among iron- Iron pyrites. masters is to call anything an iron ore which contains 20 per cent of iron, but nobody has yet made iron out of pyrite, because no economical process of eliminating all the sulphur has yet been discovered, and the merest trace of sulphur in iron renders it worthless for most purposes. The manufacturing chemists however make great quantities of sulphur and sulphuric acid, alum and sulphate of iron or copperas out of it, and when heavy veins of this mineral are well located for work and transportation they are worth looking after. The mineral itself is either whitish yellow or brass colored, is generally a mass of cubic crystalline blocks of all sizes, and each block breaks up into smaller cubes. These are very hard, will scratch a knife blade or strike fire with steel like flint, are very brittle, and will give off stifling fumes of sulphuric acid when burned in a candle flame. Pyrite occurs in scattered crystals or masses throughout the coal measures, and sometimes in the coal itself, in which case its presence diminishes the value of the coal, as iron cannot be worked with it. The principal deposits of pyrite however are in veins in the primary rocks, and frequently such veins extend upward into whatever rocks immediately overlie the primaries. These veins are nearly always indicated on the surface by spongy masses of brown oxide of iron, as in the case of the carbonates, the outcrop of the vein giving up its sulphur and becoming oxidised by exposure to the weather. Another variety of these pyritous veins contains arsenic, and the mineral is then called mispickel. It is of gravity 6.0, contains 34 per cent. iron, 20 of sulphur and 46 of arsenic; Mispickel. has a silver-white color, high metallic lustre, is very hard, and smells of garlic when heated. It is a good ore of arsenic, but not for iron. The iron pyrite veins, when in the primary rocks and of very small grained texture, can be looked into for gold with confidence.

Iron paint, or ochre, is simply oxide of iron, either naturally or artificially triturated to an impalpable powder, either pure or mixed with clay or Iron paint. other material. The limonite oxides give yellow paint and the hematitic give red, while the magnetic give black paint. Iron does not become red until it is combined into the sesqui-oxide, containing 30 per cent. of oxygen and 70 of iron.

COPPER.

Copper, specific gravity 8.9, is of fine red color, very soft and ductile, takes a high polish, but quickly tarnishes again by coating with oxide and Qualities of copper. carbonate of copper. Its tenacity is nearly as great as that of iron, but its elasticity is very low. It is found native in grains and masses in nearly all veins carrying copper ores.

Such mines as the Calumet and Hecla, near lake Superior, where they stamp and wash 800 tons per diem of rock containing 5 per cent. of its weight in shot copper or copper dust, are the paying mines. In the early days of copper mining on lake Superior a good yield of copper was obtained by small Shot copper. gangs of men washing out the sands and gravels from the stream bottoms below veins, as is done in gold districts; but the business was very small, and soon abandoned for regular mining. A peculiarity of this lake Superior copper is that much of it contains silver, not as an alloy regularly

combined, but simply disseminated through the mass in globules from the size of a pin-head to that of a walnut. These great copper veins are all powerful disturbers of the magnetic needle.

Silver in copper.

Red oxide of copper.

Cuprite, or red oxide of copper, gravity 5.9, contains 88 per cent. of copper and 12 of oxyyen. It is of a deep blood red color, semi-metallic lustre, and is generally in crystals, either cubic or octagonal. It is found in nearly all copper veins, being a product of the oxidation of some other ore, or of metallic copper itself, but it is never the principal ore of a vein.

Black oxide of copper.

Melaconite, or black oxide of copper, gravity 5.5, contains 72 per cent. copper and 28 of oxygen, is black, dark blue or brown color, and velvety in appearance. It is found with cuprite in all copper veins as a result of the oxidation of other ores, and sometimes, as at Ducktown in Tennessee, it is one of the most valuable zones of the mines.

Copper pyrites.

Chalcopyrite, or yellow sulphide of copper, or copper pyrites, gravity 4.2, contains properly 35 per cent. of copper, 30 of iron and 35 of sulphur, but the proportions are liable to all sorts of variations. It has a yellow brassy color and bright metallic lustre, but tarnishes easily. It is quite soft, and can be shaved into powder with a knife. A bright yellow and soft ore is apt to be rich, while a whitish yellow, dull colored and hard ore is poor, owing to the greater quantity of iron present. This chalcopyrite is always accompanied by pyrite, and in general the top of the vein is a brown spongy iron ore for a certain distance, then pyrite, with a little chalcopyrite, and this latter increases downwards until at a couple or three hundred feet the veinstone carries chalcopyrite almost entirely, after which it is valuable.

Gray sulphide of copper.

Chalcocite, or gray sulphide of copper, gravity 5.0, contains variably 25 to 65 per cent. of copper, 20 to 30 of sulphur, and a remainder made up of iron, zinc, antimony, arsenic and other nuisances, but it is, nevertheless, a very easy ore to work. It is steel-gray in color, dull surface and rather soft and brittle, and melts easily in the flame of a candle. It occurs in veins with pyrite and chalcopyrite, either massive and crystalline or granular. It is proper to say that the bi-sulphide of copper, which forms the basis of both chalcocite and chalcopyrite, and which does not occur as a natural product pure, contains 78 per cent. of copper to 22 of sulphur, and looks very much like metallic iron, and that the more closely chalcocite approaches bi-sulphide in composition the richer it is.

Silicate of copper.

Silicate of copper, gravity 2.1, is a compound of oxide of copper with silica and other impurities, and contains 30 to 35 per cent. of copper. It is bluish-green in color, resinous or dull glassy lustre and texture, and its fracture is like that of glass, but it is soft and easily cut with a knife; turns black when heated. This is generally rather a fancy material, but is sometimes found in the southern and Pacific coast mines in large masses accumulated by incrustations at and near the outcrops of the veins of other copper ores, but never constitutes a vein by itself, being simply a product of secondary action on the sulphides. It is a valuable ore, and profitable according to its quantity.

Green carbonate of copper.

Malachite, or green carbonate of copper, gravity 4.0, contains 56 per cent. copper, 14 of oxygen, 22 carbonic acid and 8 of water. It resembles green marble, with banded or wavy structure, is found as a precipitation in veins of other copper ores, and when in plates of any size is valuable for mantels, table tops, vases, and for all sorts of ornamental work. It is also used in jewelry, and when in large and well-shaped pieces, and of beautiful color and texture it commands a very high price, although as a source of copper it is of no importance.

Blue carbonate of copper.

Azurite, or blue carbonate of copper, gravity 3.8, is of substantially the same composition as malachite, but is of a beautiful blue color and occurs in nodules and concretions. It is used only as an ornamental material, and can

be distinguished from the blue silicate by its clearer and more gem-like appearance, and by the fact that it effervesces with acid, which the silicate does not.

In general it may be said of copper ores that they are distinguished by liveliness of colors; that they are soft; that they impart their colors to other substances by rubbing; that they nearly all turn bright green on long exposure; and that they occur only in veins in the primary rocks or rocks immediately overlying them, or in igneous rocks. In Colorado the veins are in granitic rocks, and are much given to producing malachite and cuprite ores, as well as the sulphides. General characteristics.

PLATINUM.

Platinum is a bright white metal, very like silver in appearance. Its specific gravity is 21.15 when pure, being the heaviest known metal. It is both malleable and ductile; welds like iron at a red heat, but cannot be melted by any heat less intense than that of the compound blowpipe. It does not oxidise or tarnish, and is not attacked by any single acid. It is never found as an ore, nor yet pure, but always in the metallic form allied with other metals, and one of the most tedious processes in chemistry is that for purifying platinum. It is nearly always alloyed with the metals osmium, rhodium, iridium and palladium, one or two of which are thought to be as heavy, if not heavier, than the platinum, but the quantities for testing this are so minute as to make accuracy difficult. Platinum is found along with gold in the sands of the streams of the primaries. It is in flattened grains and small masses, the native alloy having a gravity of 17 to 19, and having generally angular corners and occasionally black dots on the dull white surface of the grains. It is found with gold in Russia, Australia, South America and in the United States, but only sparingly in this latter country. Qualities and ocurrences.

MERCURY.

Mercury, or quicksilver, specific gravity 14.4, is a brilliant silvery white metal, liquid at ordinary temperature but freezes solid at 40 degrees below zero, Fahrenheit, and when thus frozen can be hammered out into plates or drawn into wire, and can be welded like iron. It occurs naturally in the metallic state in globules disseminated through the rocks, as the result of natural reduction from its principal ore, the sulphide of mercury or cinnabar. Qualities.

Cinnabar, gravity 9.0 to 10.0, contains 80 to 90 per cent. of mercury, and 10 to 20 of sulphur, is a vermilion red granular ore, sometimes in compact masses, and again like loose red earth with a yellowish tinge. It will evaporate entirely if thrown on a red-hot shovel. This ore is the only ore of mercury worth looking for, and all the mercury we know of is in the rocks above the lower primaries, owing to its extreme volatility. It is rarely found actually in veins, but is apt to be disseminated through the neighboring rocks, no matter what rocks they may be. Cinnabar.

NICKEL.

Nickel, specific gravity 8.82, is a brilliant silver-white metal, very malleable and ductile, and does not oxidise at ordinary temperatures, being therefore very valuable for cheap coins and cheap spoons and other ware. It occurs in the metallic form naturally only with metallic iron in meteors, and for all practical purposes it is extracted from its ores. Qualities.

Copper-nickel, gravity 7.0 to 7.5, contains 45 per cent. of nickel to 50 per cent. of arsenic and 5 of iron, lead, sulphur, etc., but no copper, its name coming from its copper-like appearance. It is hard and brittle, and generally fine grained, and of high metallic lustre. Its powder is almost black, and the fresh surface of the ore soon tarnishes, first to grey, which deepens with time to black. Copper-nickel.

Sulphide of nickel. Sulphide of nickel, gravity 6.5, contains 65 per cent. of nickel to 35 of sulphur, is a mass of grayish to yellow flexible threads, having a metallic lustre. This material is very rarely found pure, but is nearly always mixed with antimony or with iron pyrites, as follows:

Nickel glance. Nickel glance, gravity 6.5, is sulphide of nickel and antimony, and contains 28 per cent. of nickel, 17 of sulphur and 55 of antimony. It is steel gray in color, metallic lustre, very brittle, and occurs in masses with a granular texture, the grains being almost cubic.

Magnetic pyrites. Magnetic pyrites, gravity 4.5 to 5.0, is a compound of the sulphides of nickel and iron, and contains generally about 20 to 25 per cent. of nickel. It is massive, very brittle, metallic lustre, and dark brass or orange colored. It is slightly magnetic, and, although not so rich in nickel as the other ores, it is the source of nearly all the nickel supply by reason of its greater abundance.

All nickel ores are found in veins in the primary or lower secondary formations, and the ores are rarely found except in association with cobalt ores mixed with the ores of copper, lead and other minerals, as spoken of under the head of cobalt.

COBALT.

Properties and uses. Cobalt, specific gravity 8.5, is a lustrous, reddish gray metal of granular texture and very brittle. Its texture can vary from granular to fibrous or laminated, according to the degree of heat used in its reduction from the ores. Metallic cobalt is never found native, and its reduction from its ores is exceedingly difficult as it is so much like nickel in all its properties, and the two are always associated. Metallic cobalt is not useful except as specimens in cabinets, etc., but its combinations with oxygen and other elements give us smalt, and azure, and ultramarine, and all the beautiful blue coloring matter for glass.

Arsenical cobalt. Arsenical cobalt, gravity 7.3, is a silvery white mineral containing 30 per cent. cobalt, 60 of arsenic and 10 of iron, copper, sulphur and other impurities. The silver white color is only on fresh fractures, the external surfaces tarnishing to reddish gray. Texture compact to granular. It is brittle but can be cut with a knife, and its lustre is metallic.

Cobalt glance. Cobalt glance, gravity 6.5, sometimes called smaltine, contains 35 per cent. cobalt, 50 of arsenic, 20 of sulphur and 5 of iron and other impurities. Its color is tin white, with a light red tinge, shining metallic lustre, and is in well-defined rather cubic crystals, slightly lamellar in structure. It is not brittle, cuts with difficulty, and both this and arsenical cobalt give off an odor of garlic if held in the flame of a candle.

Sulphide of cobalt. Cobalt pyrites, sulphide of cobalt, gravity 6.3, contains 43 per cent. of cobalt, 14 of copper, 40 of sulphur and 3 of iron, etc. Its color is steel gray, inclining to yellow. It is found in grains or granular masses, the grains being cubic in shape.

Oxide of cobalt. Oxide of cobalt, gravity variable as found naturally, looks just like black earthy oxide of manganese or wad, and is nearly always mixed with it, so that the character and value of the mixture depend entirely on its constitution.

Occurrences. The cobalt ores are always found with nickel ores in the veins and deposits in the primary and lower secondary formations, and frequently mixed with copper or lead ores, as in Missouri, where in some mines the lead and copper are powdered over with bluish semi-oxidised arsenical and sulphide ores of cobalt and nickel, and some seams of the clay slates are spangled with dots of these ores.

TIN.

Tin, specific gravity 7.29, is a silvery white metal of high metallic lustre. It is very malleable and soft, but owing to its crystalline texture it is not ductile, and has almost no tensile coherence, and has therefore to be used in

alloys or as a coating to other metals. It oxidises with great difficulty at ordinary temperatures, and is therefore very useful as a surface coat for other metals such as iron and copper. It is said to have been found pure in Russia and elsewhere in Europe, but only in small grains, and is derived entirely from tin ores for commercial use. Properties.

Tin stone, or binoxide of tin, gravity 7.0, contains 78 per cent. of tin and 22 of oxygen. It is a peroxide, *i. e.*, it cannot be further oxidised, and is also called cassiterite. It can be gray, yellow, red or black in color, is of a brilliant lustre, and hard enough to strike fire on steel. It is found in veins in the granites and slates of the primaries, and is also found as grains in the beds of streams, and is then called *stream-tin*. It is the principal ore of tin, and produces perhaps 95 per cent. of all the tin the world uses. The principal tin-producing countries are Cornwall in Britain, and Tasmania and other Australian colonies. Tin stone.

Tin pyrites, or sulphide of tin, gravity 4.4, contains generally 26 per cent. of tin, 30 of copper, 12 of iron and 32 of sulphur, and as it is a copper pyrite or iron pyrite as well as a tin pyrite, the miners compromise by calling it "bell metal ore." At all events there is very little of it, it occurs in veins in the primary rocks, and is as often worked for copper as for tin when it is found. Its crystalline form is cubic and very similar to iron pyrite, and it leaves a black streak on a hard white surface. Sulphide of tin.

ANTIMONY.

Antimony, specific gravity 6.7, is a silver-white metal of brilliant lustre and crystalline texture. It is very brittle and can be pulverised with a hammer. It is not sensibly affected by exposure to air at ordinary temperature, but tarnishes slowly, although it does not rust. It is only useful as an alloy, being too brittle to be used alone. It is found in the metallic state as an alloy with a great many other metals, but its principal useful occurrence is in combination with sulphur. Qualities and occurrences.

Sulphide of antimony, gravity 4.5, contains 72 per cent. of antimony and 28 of sulphur. It is a leaden gray in color and of metallic lustre, unless tarnished by oxidation. It is both massive and fibrous, like bunches of needles, and can be granular. Its powder is gray and turns black and irridescent on being heated and will melt in a candle flame, giving off fumes of sulphur. It is found in the veins of the primaries and secondaries, intermixed with the lead and zinc ores and with the carbonate of iron ores and sulphate of barytes, quartz and other minerals. There are oxides of antimony as well as other antimonial minerals, but they are of secondary origin and very rare occurrence, and therefore of no commercial value. Sulphide of antimony.

ZINC.

Zinc, specific gravity 6.8, is a brittle bluish white metal, very lustrous and of a crystalline foliaceous texture on freshly broken surface. It is never found pure in nature, but is extracted from its ores. Qualities.

Sulphide of zinc, black jack or zinc blende, specific gravity 4.0, contains 66 per cent. of zinc to 34 of sulphur and impurities. It is of yellowish brown color generally, but can grade down to black and bluish black. It looks like masses of agglutinated crystals of brown honey or clear resin. It occurs in all the formations between the Huronian and the Carboniferous, and in some of the gold and silver mines it is a very abundant gangue rock and choice nuisance, silver ores mixed with black jack being the most difficult to treat. The zinc, which is only worth six to ten cents per pound, insists on being attended to first and acts generally as though it thought that the gold and silver were mere incidentals. Where mother nature has had time however she teaches this black jack to be useful by desulphurising it itself and thereby forming the carbonate and silicate of zinc. Sulphide of zinc.

Silicate of zinc. Silicate of zinc, or calamine, gravity 3.4, contains oxide of zinc, 71 per cent., 25 of silica and 4 of iron and lead; the oxide of zinc producing from 50 to 60 per cent. of metallic zinc when measured on the weight of the original mineral calomine. Miners call this ore and the carbonates of zinc and lead all "dry bone," because sometimes they look somewhat cellular like old bone, although calamine most frequently is glassy, lustrous and transparent and is generally colorless, but occasionally grayish to yellowish. This is one of the principal ores of zinc, is a secondary product from zinc blende and is found most plentifully in the limestones of the Silurians. It can occur in veins or in washed deposits from broken down veins, the debris of which has been incorporated as part of subsequent formations.

Carbonate of zinc. Carbonate of zinc, or smithsonite, gravity 4.4, is very similar to silicate and is even yet called calamine by some engineers. It is softer than calamine and heavier, and will effervesce with acids. It contains 65 per cent. of oxide of zinc and 35 per cent. of carbonic acid and impurities, the oxide of zinc panning out about 50 per cent. of zinc, measured on the original weight of carbonate of zinc. This ore and the silicate produce nearly all the zinc used in America. They are always found together and always where their descent from black jack can be traced with time and opportunity to devote to the problem.

Oxide of zinc. Oxide of zinc, gravity 5.5, contains 75 per cent. of zinc and 25 of oxygen and impurities. It is red or reddish yellow, brilliant lustre and is translucent, occuring either in grains or in foliated masses like mica, but the leaves are brittle. This ore accompanies black jack in the veins of the primary rocks as well as in the Silurians. It is the richest of all the zinc ores and perhaps the most easily worked in the furnace, but it is not an abundant ore, and therefore not important as compared with the silicates or carbonates, although it is much used for making paint.

LEAD.

Properties. Lead, specific gravity 11.445, is a soft bluish gray metal, of high metallic lustre when freshly cut, but tarnishes almost immediately; leaves a black mark when rubbed on paper; very ductile. It is rarely or never found pure in nature, but is extracted from its ores.

Sulphide of lead. Galena or sulphide of lead, gravity 7.7, contains 86 per cent. lead to 14 of sulphur; is of leaden-gray color, high metallic lustre and nearly always is a mass of cubic crystals which are very brittle and easily powdered into black dust. It melts and gives off sulphurous fumes when heated. It nearly always contains more or less silver, which frequently is enough to pay for extraction; in fact many of the great silver mines of the world are simply galena veins, which are worked primarily for the silver, and the lead saved after reducing the silver is then sold as a secondary product. Galena is the mother source of all lead,the other ores being the result of reaction on the sulphide by other agents. It occurs primarily in veins, but also in beds and pockets, these being vein materials washed down or dissolved and re-deposited. The veins are most frequent in the primary rocks, but they are found all the way up among the formations to the base of the carboniferous, where the veins are larger than in the primaries but not so frequent. A feature of galena veins is that in limestone they are largest and diminish down through sandstones, and are smallest in the slates of the primaries. The Silurian and Devonian limestones, lying immediately on or separated from the slates by very thin members of the same groups, as in the Mississippi valley, appear to be the best places to look for galena veins and deposits, while the great silver-bearing lead deposits of Utah and other western localities appear to have very little system in their modes or locations of occurrence.

Cerussite or carbonate of lead, gravity 6.5, contains 77 per cent. of lead when pure mineral, but except as cabinet specimens it is never found pure:

60 to 65 per cent. of lead is its practical yield, the balance being oxygen, carbonic acid, silica, iron, zinc and other impurities. The pure mineral is in translucent grayish white crystals, but the ore of lead is known as "dry bone" on account of its appearance. It is generally a little porous, of white or yellow or reddish-yellow color and looks much more like masses and cakes of clay than anything else, and, unless its weight reveals its nature, it is apt to be thrown aside. It is found with galena and is frequently the outside of a mass of which the inside is galena not yet entirely changed to cerussite, and in such cases the mass looks like compact ashes. It does not form veins or great deposits by itself, but its presence is a good indication that galena is near and there is sometimes enough cerussite with the galena to pay for extraction. Carbonate of lead.

Pyromorphite, or phosphate of lead, gravity 6.8, contains 55 per cent. of lead and is a green or yellow earthy-looking indeterminate crystal or mass of crystals, covering cerussite or galena as an incrustation. It is a secondary product and is chiefly valuable as an indication that galena is to be found below, the pyromorphite generally showing at the outcrop of veins or deposits. Phosphate of lead.

There are oxides of leads made artificially for painting purposes and a sulphate of lead which effloresces over galena deposits, and there are other minor occurrences of the compounds of this mineral; but they are all secondary products of galena, and except those named they are not even reliable indications of the proximity of lead and are nearly indistinguishable from ordinary clays and earths. Other compounds.

CHROME.

Chrome, specific gravity 6.0, is a grayish white metal of radiated and crystalline texture, very hard and brittle. It is never found native and can only be reduced from its ores with great difficulty, and is therefore rarely used in its metallic state, but mostly in combination with oxygen, making chromic acid, which combines with potash and other bases to make coloring matters. Occurrences.

Oxide of chrome is chrome with one part of oxygen, and in this form it is translucent and crystalline, of green to yellow color, and the crystals can be large or so small as to be merely dust. This mineral combined with oxide of iron makes the chromic iron ore from which all the chromic salts used are produced. Sometimes in this ore the two oxides are simply mixed, and sometimes the oxide of chrome takes up the oxvgen out of the iron and becomes chromic acid, when it attacks the iron and forms chromate of iron, which is the most usual form of chrome ore. This ore again is mixed with alumina and magnesia and occasionally silica, in which last case it is valueless, the silicious ores not yet having been economically reduced. The general appearance of chromic iron ore is that of agglomerated masses of crystals, apparently stuck together with white or yellow paste. The crystals are usually about as large as No. 1 shot and of black or greenish black color, with a gravity of 4.5 to 5.0. The masses of crystals are very hard, but very brittle, and the amount of oxide of chrome obtainable is from 40 to 60 per cent. It is nearly always found with serpentine, and never outside the limits of magnesian rocks. The principal sources of supply are the serpentines of the Atlantic states and similar formations in California. Oxide of chrome.

MANGANESE.

Manganese, specific gravity 8.0, is a grayish white metal of very mild lustre, fine granular texture, rather soft and very brittle and oxidises very rapidly. It is very difficult to obtain pure, and unless produced by a careful and complicated chemical process it contains carbon and then resembles cast iron both in appearance and quality, varying principally in being more brittle Properties.

and so hard as to strike fire and scratch the best steel. It enters into alloys with pretty much all the other metals, and makes them harder and whiter as well as more brittle. It is never found in the metallic state in nature.

Peroxide of manganese.

Pyrolusite or peroxide of manganese, gravity 4.8, is a black to blackish brown shining mass, sometimes velvety or fibrous in appearance and contains 63 per cent. of manganese to 37 of oxygen. It is found in veins in the primaries and lower secondaries and nearly always more or less mixed with oxide of iron, making a compound ore which when combined in proper proportions smelts into ferro-manganese, a very useful substance for physicking Bessemer and other steel. Spiegeleisen is one of the varieties of ferro-manganese, these special compounds being smelted from ores either naturally or artificially mixed. This ore of manganese is used extensively as a producer or yielder of oxygen for all sorts of laboratory uses and for bleaching purposes. When this ore takes up water and becomes hydrated it is called psilomelane, so long as it remains in the veins with the pyrolusite, where it is found often in streaks through the last named.

Sparry manganese.

Sparry manganese, gravity 3.6, contains 53 per cent. of oxide of manganese, 40 per cent. of silica and 7 per cent. of iron, lime, magnesia and water. It occurs with the other manganese ores and usually in crystalline masses, flesh-red in color, but can be brown to yellow and even green and is semi-transparent generally, but sometimes opaque and is nearly always black on long-exposed surfaces.

NATURAL PAINTS.

Mineral paints.

Natural paints are those minerals which, when finely powdered and mixed with oil, will adhere to any surface upon which they may be spread, and in time form a skin or film hard and impermeable enough to protect the surface from ordinary weathering.

Red iron paint.

Red iron paint is composed of oil mixed with the red powder of pulverised sesqui-oxide of iron, the ores for this purpose being the gray or red oxide, *i. e.*, the specular and red hematites described under the head of iron and its ores. The sesqui-oxide of iron contains 70 per cent. of iron and 30 of oxygen, and is the richest possible *red* iron paint, for the reason that no iron oxide becomes red until it takes up 30 per cent. of oxygen, notwithstanding the efforts of certain paint makers who guarantee their red paint to contain 72 and even 90 per cent. metallic iron. The red paint made by complete pulverising of the gray sesqui-oxide, or the red dyestone hematite ores, with very heavy machinery and conscientious care, is a first-class paint, and possesses merit enough of its own without any 90 per cent. guarantee or sailing under false colors.

Yellow iron paint.

Yellow iron paint is the powder of pulverised hydrated sesqui-oxide of iron, commonly called limonite or brown hematite iron ore. When pure this ore cannot contain more than 60 per cent. of iron, but by mixing with the anhydrous oxides the color is darkened and the metallic percentage increased nearly up to that of the red or black oxide.

Black iron paint.

Black iron paint is the powder of pulverised black oxide of iron, this being the magnetic ore, and contains when pure 72 per cent. of iron. This ore is a proto-sesqui-oxide, and is the richest possible stable or fixed compound of iron and oxygen, the proto-oxide changing into this by taking up more oxygen on the first exposure to moist air. This black powder mixed with the red or yellow powders gives a very wide range of colors, and all in first-class metallic oxides.

Umber.

Umber is of variable shades, but is produced by mixing the iron paints with powdered oxide of manganese, which gives a purplish gloss to the iron colors.

Red and green copper paint.

Red copper paint is the pulverised red oxide of copper, and is rarely made for use out doors as the ore is too valuable. Green copper paint is the pulverised green silicate of copper and is a fancy color.

Zinc white is the oxide of zinc, and is not found pure enough in nature, so that it has to be manufactured with great secrecy at large and costly establishments. Zinc white.

White lead is carbonate of lead, which also is made in large establishments and under complicated processes, the native carbonate ores of lead not being pure enough. White lead.

Red lead is an oxide of lead, and has to be carefully manufactured by experts. Red lead.

Vermilion is pulverised cinnabar, the sulphide of mercury. Vermilion.

Spar paint is pulverised barytes. It makes a tolerable paint, very white in color, and is the best thing to mix with white lead or zinc paints, if you will have adulterations. Spar paint.

Cement paint is any kind of lime mixed with vegetable oil instead of water, as in the case of whitewash. There are some of the cements which make a most admirable paint when ground in oil. Cement pain

Slate paint is simply selected scraps of fine-grained slates pulverised and mixed or ground in oil. When used in very thick coats the slate paints become fireproof, and mixed with india rubber, or sometimes asphaltic mineral, they make good roofing. Slate paint.

Graphite paint is pulverised pure black lead or graphite. This is very fine and glossy, and can be made into a fireproof coating for roofs and other surfaces. Graphite paint.

Red ochre is fine clay containing enough red iron ore to tint it. It can be made artificially by mixing red iron paint with clay, but the fine natural ochres are the most valuable by reason of the immense amount of assortment and trituration which they have undergone, and which man has not yet successfully imitated except by expensive chemical precipitation. It is possible that a mixture of iron paint and hydraulic cement or lime might prove very valuable. Red ochre.

Yellow ochre is any mixture of clay with brown iron ore, and can be prepared artificially, as with red ochre, but the natural mixture is the best. These ochres when mixed with manganese make the different shades of umber. The difference between the metallic paints and the ochraceous paints is merely that the metallic paints are the pure oxides, while the ochres have more or less clays mixed with them. All natural paints should be carefully assorted into lumps of uniform color and texture before being powdered, or the result will be variable. The yellow iron paints and ochres change to red by burning, *i. e.*, the water of hydration is burned out of the limonite iron ore, leaving it a red hematite. Yellow ochre.

PROF. CLAYTON'S ADVICE TO PROSPECTORS.

1. Examine the gravel and boulders of the mountain streams, and note carefully the structure and character of the gravel wash. This will reveal the geological formations that are intersected by the stream. Try the sands at the head of the gravel bars for free gold or for any crystallised minerals. If the structure of the quartz boulders or other vein stones is favorable, go up the stream until the geological zone is found that has produced the quartz or other metal-bearing minerals. Then follow the supposed metal-bearing zone on its line of strike, and make especially careful examinations wherever eruptive dykes are found intersecting the formation. In mountain regions.

2. When a lode or vein is found, note carefully its relation to the country rock, especially any differences in the opposite walls of the vein. Then follow it on the line of outcrop, and note carefully those points where the best ores are seen, so as to determine the position of the best ore chutes before making any location on the lode. On discovering a lode.

3. The first work should consist of shallow cuts across the lode at intervals of 50 to 100 feet, or if the vein is small and partially covered by soil and debris, a trench along the line of outcrop is preferable. First work.

Exploring under ground

4. The work of exploring the vein under ground is the next thing in order. To do this intelligently you must select that point on the line of outcrop where the best ore is found, then sink a shaft on the lode following the angle of dip, keeping both foot wall and hanging wall exposed if possible. If the lode is too wide for this to be done, then follow the best ore streak of the vein itself, and at every fifty feet in depth make cross-cuts to the walls of the vein.

inking shaft and running levels.

5. After 100 feet deep has been reached, run levels each way from the shaft on the line of the vein in order to determine the extent or spread of the the ore chute or chimney on the horizontal line. When the limit of the ore body on the horizontal line has been ascertained, then sink 100 feet more, and drift right and left as before. If more than one chimney of ore is found on the line of the vein a shaft should be sunk on it and drifts run as above stated, being careful to confine all the exploring work within the walls of the vein itself.

Dead work.

6. When enough has been done to prove the character, size and quality of the vein, it will then be time to determine the position, character and extent of the 'dead-work' necessary to work the mine to the deep. These questions should be settled by careful surveys made in the light of all the local facts and surroundings, such as the geological structure of the country rock, the probable amount of water to be raised, the lowest point of drainage by adit or level, and the most convenient point for the delivery of the ores to the surface, etc. The last part of the preliminary exploration of any mine is to determine by actual tests what are the best methods of reduction, and the extent and kind of reduction works needed, etc.

Methods of reduction.

Requirements for subsequent operations.

7. After all these preliminary facts have been thoroughly ascertained and clearly defined, the unavoidable risks of mining will have been fully met and overcome. All subsequent operations are simply matters of skill and business management, and the capitalising of the mine becomes a mere matter of business detail. The requirements are as follows:

(1) The preliminary exploration must have ore enough cut and underrun, or otherwise exposed, to give at least two years' work for reduction works of an extent sufficient for the annual average output of ore.

(2) The reduction works must be suited for the best treatment of the ore.

(3) The exploration of the mine must be pushed ahead of the extraction of ore, so as to expose at least one ton of ore in new ground for every ton extracted from the previously explored ground.

(4) Before erecting reduction works the ore exposed in the mine should be so thoroughly tested as to guarantee a net profit sufficient to pay the whole cost of such work.

(5) The mine being well opened and the reduction works or plant established, the general success of the enterprise must depend upon the efficiency of the general business management.

G.—EXPLORING FOR IRON ORE.

BY WILLIAM COE, ONE OF THE COMMISSIONERS.

Iron ore wealth of Ontario.

The iron ore deposits of our province have as yet remained practically undeveloped. A few mines have been opened and some shipments of ore made, proving their extent, their richness and their great commercial value; but what has been done is simply a drop in the bucket compared to what remains to be done. The wealth yet to be mined is simply incalculable. There remains in nature's storehouse of underground deposits treasures which, if a business was once opened by their working and manufacture in various ways, would bring this province into a prominence that no other com-

mercial enterprise could approach. The results would be a great increase of population, an active transportation service both by rail and water, and an influx of capital surpassing any calculation that might be formed of what is likely in this respect. Our present mineral enterprises are so recent that public attention needs to be drawn to the subject in a marked manner in order that the magnitude of our iron and other ore resources may be fully comprehended, and steps be taken to inaugurate some means of bringing into a practical shape its mining and manufacture, at least to lead to a beginning of what may become a profitable industry among our own people and a vast commerce with our neighbors.

OCCURRENCE OF IRON ORES IN ONTARIO.

Occurrence of iron ores in Ontario.

Iron ore is principally to be found in Ontario in the Laurentian and Huronian formations. The Laurentian hills, as the geologists term them, are the oldest in the world. They occupy the principal portion of this province, stretching from the Ottawa river to the Georgian bay, and thence along the north shore to the head of lake Superior. In these no indications of animal life can be traced. The hills are of all shapes and dimensions. The region in which they occur is all underlaid with rock at a slight depth, and it crops out in vast beds, boulders, high ledges and numerous cliffs. The hills and valleys are covered with pine, hemlock, cedar, tamarac, etc., and have been but little explored except by lumbermen who there carry on year by year their operations. The rocks composing the Laurentian formation are of different classes, the principal being granite and diorite intermixed with bands of crystalline limestone. The limestone occurs in large patches, mostly broken within the first twenty or thirty miles of the southern limit of this formation. It is in contact with these or near them that the iron ores are found. The stratification of the Laurentian rocks is very irregular and contorted, and they dip at all possible angles. There are two sets of veins crossing some parts of it, one striking northeast and southwest, and the other crossing on the opposite points of the compass; and surface indications lead to the finding of iron ore deposits. The ores are generally known as hard and soft; the former includes the magnetic and specular, while under the latter are classed all those known as hematites.

Hard and soft ores.

INDICATIONS OF ORE BODIES.

Use of the magnetic needle in prospecting.

The use of the magnetic needle has frequently led to the discovery of ore deposits, although its deviations do not determine the certainty of a deposit; yet experience has proved that where these occur is a good place to look for ore. Sometimes the magnetite in the rocks causes these fluctuations, but notwithstanding this, faith in the needle has been frequently followed by the discovery by prospectors of very promising mines. No one can tell with certainty what the origin of ore deposits is, and the only way to find them is by careful search in such variety of rocks as similar ores have before been found in. Sometimes there are indications which an expert seizes upon as a guide to prosecute a search when they occur, with generally fortunate results. Magnetic ores are frequently found with a large body of green and granite rock on the north and a body of quartzite on the south side. Frequently these may be at a considerable distance from each other, but in the interval between them there may be found a body of ore. These rocks when they come closer together form the walls of the vein enclosing the ore. Their distance apart can be calculated upon as a means to discover the depth of the deposit, it being generally considered that the point where they meet together underground will be the depth of the deposit. Frequently timber of fine growth in the iron formation indicates the presence of iron ore, as a good many mines have been found when the timber is straight and of good size, clear of underbrush, and of better quality in comparison with other trees of like kind in that vicinity. Where the timber is good and iron ore is found, it is generally

Magnetic ores in certain formations.

Timber as an indication of ore.

first-class, but where the timber is of poor growth and a mixture of all kinds of scrubby wood the ore as a rule is of inferior quality. Invariably very fine springs have been found where mines of a permanent character have been located. None of these are infallible signs, but all have their bearing on the subject, and frequently attention to them will be rewarded with good results. Magnetic ores are generally found in beds. They are of all sizes, from those yielding a few tons to those containing enormous quantities.

Hematite ores connected with limestone.

The hematite ores already discovered in Ontario have been found closely connected with the lime rock, this formation being of a later date. We believe that in working the hematite finds a great number of good mines will be found heavily capped with lime rock. These hematite ores may yet prove to be the most valuable in the country, and to produce a great output of one of the materials necessary to mix with the hard ores in the manufacturing of a high grade of charcoal steel.

Use of the diamond drill.

The opinion is that the hard ores run to a very considerable depth. This can only be tested by the use of the diamond drill, which is a quicker way of arriving at results than by sinking shafts. After finding ore in place, the ordinary way of proceeding is to cross-cut the vein on the surface to ascertain its width, as well as to determine the character of the rocks on either side to see that the formation is right, and then use the diamond drill to determine the depth and quality of the ore before deciding what is necessary to be done further. A great deal of preparatory work has to be accomplished and considerable expense incurred before it becomes a mine proper.

PRACTICAL SUGGESTIONS TO EXPLORERS.

Aimless prospecting.

During their travels through Ontario the Commissioners were constantly meeting explorers who did not seem to have any idea in reference to a starting point to their working, but were travelling through the region at random, trusting to chance to make a discovery. Quite a few had spent months unsuccessfully in pursuit of what they would have been able to determine in a very short period had they the necessary knowledge to guide them.

It has therefore been deemed advisable to give a few practical hints, gathered from the observation and experience of one who has been actively engaged in explorations and developments in this province during the last eighteen years, for the assistance and guidance of explorers as well as others.

Granite ranges should be explored thoroughly.

In every section of the country where minerals are found, the granite formation is the most prominent among all the rocks, running north and south or on that strike. This granite range is the first that should be explored thoroughly, keeping near to it, and on the easterly side of the ridge. This will be found a good starting point, as the granite is the oldest formation, and as the course of the iron ore is in a westerly direction it follows naturally that near the granite the heaviest bodies of ore are to be found. Iron ore outcrops running north and south in the middle of any formation, and not near the granite, as a rule will not make permanent mines. It is believed generally that diorite, or "green rock" as the miners term it, is the matrix of iron ore, but still if an outcrop of iron ore is found in the centre of and surrounded by this green rock on all sides, it will not as a rule make a permanent mine. The writer gives it as his firm opinion, justified by facts, that no iron deposit surrounded on all sides by the same kind of rock will be lasting. Sometimes large outcrops on the surface have been found in these occurrences, but in every instance on practical working both by the hammer and drill and by diamond drill boring, such occurrences have been exhausted at short depths. It is judged as being useless to spend money on iron ore deposits unless they are found with the granite on one side, and then between the granite and ore diorite or green rock occurs (the latter sometimes in considerable abundance, and again not more than two or three feet thick), and on the other side of the ore quartzite or crystalline lime rock. The reader

Permanent mines are not to be looked for in rock of uniform character.

Distinct formations assure a permanency of ore deposit.

will perceive that this gives a distinct formation, which experience goes to prove assures a permanency of deposit. Another feature of a permanent mine is that there is a distinct cleavage between the ores and the walls enclosing it. Where these conditions do not accompany the deposit, the ore being encircled with the same class of rock is liable to be cut out at any time, and a find of this kind is only looked on as being fit to work while the deposit is in sight and does not justify the purchase of machinery or erection of works. Sometimes as much as 5,000 or 10,000 tons may be taken out of these occurrences of ore, but there is no dependence to be placed on them as mines for permanent work.

Distinct cleavage between walls and ore.

The dipping to the north of an iron deposit is a very important feature in connection with its permanency. This northerly dip is caused by the abundance of ore in the mine, and its consequent attraction in that direction toward the North pole. In some instances large deposits of ore occur dipping to the south near the surface, but at a further stage of development these dip to the north, which is a sure indication of a large body of ore.

Northerly dip of the ore body.

The idea which still prevails with a few that iron mines are to be discovered by chance in any kind of rock has long ago been exploded, and with mining experts it has become a settled question that no permanent mines are to be discovered except in formations with the conditions above stated.

An exploded idea.

We may add that a large part of the best mines now being worked in the Marquette district have been found at great depths. These discoveries were made through actual workings in a regular formation although no trace of them were seen on the surface, showing that in working in a right formation large bodies of ore are constantly being found,.although away from and apparently thrown off from the mine proper. This is accounted for by the ore coming in contact with an older formation of rock which does not show at the surface. In developing the additional find we are able to meet with the same occurrence in drifting to either the north or south, or in using the diamond drill, which goes to prove that having once located ourselves in the iron formation proper there is no end to the possibilities of continuing to find bodies of ore. This experience never takes place except where the iron formation is regular on the surface as above stated.

Iron deposits in the Marquette district.

ORES MOST IN DEMAND.

The ores most in demand are those suitable for the manufacture of Bessemer steel. It is a necessity that ores to be used in its manufacture must be free from phosphorous, as a small percentage of this destroys its value, the presence of one five-thousandth of its weight in phosphorous rendering the steel brittle. Ores for this purpose are rated more with reference to the percentage of phosphorous they contain than for their richness in iron. The presence of titanium is very prejudicial to the quality of the ore, this substance eating out the sides of the blast furnaces, and consequently furnacemen will not use ores largely containing this material as they will destroy the walls of the furnace and entail a very heavy expense in repairing it, besides being very injurious to the iron produced. An excess of sulphur is also a defect, and ores containing over a certain limited quantity of this material are practically outside the market. An analytical chemist will have to be consulted to determine these matters, as it is a question of chemistry which few explorers have any knowledge of.

Phosphorous.

Titanium

and sulphur in iron ores.

The Huronian formation covers a large broken area between the western outlet of French river on lake Huron and the head of lake Superior. It is more recent than the Laurentian, which it more or less overlies. It consists of green and grayish slate rocks mixed up with masses of greenstone, and abounds in numerous trap dykes. It contains many quartz veins bearing valuable minerals, besides large deposits of iron ore of first class quality.

The Huronian formation.

H.—NOTES ON CHARCOAL AND CHARCOAL IRON.

BY JOSEPH BAWDEN, BARRISTER-AT-LAW, KINGSTON.

Canada's mineral wealth and mining inactivity.

The writer of a paper in Iron on the properties and occurrence of iron ores says: "Canada is pre-eminently rich in iron ores, but the greater number of the deposits are undeveloped, owing to want of energy, of accessible fuel, difficulties of transit, etc. In fact throughout the whole of the country mining may be said to be in its infancy, and little attention has been paid to the developement of the vast mineral wealth that the country possesses." Again: "Canada is pre-eminently rich in red hematite, but comparatively little attention has been hitherto paid to the developement of the iron ore wealth of this vast extent of country. Many of the Canadian iron ore mines are stock-formed, a fact which may partly account for the want of enterprise shown by the inhabitants." *

So far the great journal of the British iron industry, and whether it is due to stock companies or want of energy the fact is not less surprising that in the year ending 30th June, 1887, the United States imported from England 72,546 tons of iron ore and only 18,430 tons from Canada. Our neighbor's total import of iron ore in the same period was 1,141,774 tons, of which it will be seen our share was little more than one and one-half per cent. The output of the United States iron mines during the year 1887 was estimated at 11,300,000 tons.

CANADA'S IMPORTS.

Canada's iron and coal imports from the United States in 1887.

Canada imported from the United States in 1887 over $100,000 worth of agricultural implements. American car wheels were imported to the value of $7,759, or to the weight of 3,004 cwt. The number of American locomotives imported was thirteen, of the value of $72,804, or on an average of $5,004 each. American hardware was imported to the value of over $720,000, more than half of which was builders' hardware. A great many American locks found sale north of the lakes—$69,845 worth. Iron in slabs, blooms, etc., was imported to the extent of 11,227 cwt. Machines and machinery were taken to the value of nearly $1,500,000. Nails and spikes of American production were also imported in large quantity—wrought, 193,801 lb., including railroad spikes: cut, 154,911 lb. Over 10,000 tons of pig iron were also imported. During the same year Canada also imported from the United States cutlery to the value of about $50,000; files and rasps, $35,912; saws, $55,395; axes, $7,556; all other mechanics' tools, $194,018; and many score of other iron and steel products. Of steel rails 82,980 cwt. were imported. Of American coal, 949,499 tons of anthracite and 1,077,678 tons of bituminous were imported, besides 31,162 tons of coal dust and 13,518 tons of coke. Canada also imported from the United States under special exemption from duty for the construction of the Esquimault and Nanaimo railroad the following: "Bolts and nuts, 19,070 lb.; fish plates, 77,804 lb.; spikes 44,000 lb.; steel rails, 1,334,000 lb." *

PRODUCTION IN THE UNITED STATES.

United States production of iron and steel.

The quantity of pig iron made in the United States in 1887 was 7,187,206 tons of 2,000 lb. According to fuel used this production was classified into anthracite pig 2,338,389 tons, charcoal 578,182 tons and bituminous 4,270,635 tons. Our conterminous neighbors make the larger part of the charcoal pig production, viz: Maine (charcoal pig only) 4,397 tons; New York, 26,491; Ohio, 18,544; Michigan, 213,543; Wisconsin, 47,523 tons. Of the total pig iron the product known as Bessemer pig stands for 3,202,153 tons. The total production of Bessemer steel in the same period was 3,288,357 tons—an increase of 30 per cent. over the previous year. The production of open hearth steel was 360,717 tons—an increase of 47 per

* Iron, vol. XXXI, pp. 73 and 339. † Iron, Nov. 16, 1888.

cent. over 1886. Of crucible steel there was produced 84,421 tons. The returns for the first half of 1888 show production less than the corresponding half of 1887 as follows: Anthracite pig, 992,461 tons, being a decrease for the half year of 144,482 tons, with 23 furnaces out of blast between 1st January and 1st July, 1888. The charcoal pig production was 278,238 tons, being an increase of 15,190 tons over the previous corresponding half-year; and of bituminous pig 2,111,804 tons, being an increase for the same period of 161,465 tons. Of 587 furnaces, 297 are out of blast. Much of the larger part of the pig iron classed as anthracite pig is made with a mixture of anthracite coal and coke. The quantity of iron made with anthracite alone is steadily growing smaller. In the first half of 1888 it amounted to only 107,802 tons. The proportion of Bessemer pig shows a decrease of 152,200 tons, attended with a falling off in the production of Bessemer steel ingots and rails from the corresponding half-year of 1887 to the extent of 257,284 tons. Iron Age, the excellent journal of the American iron trade, gives the following estimate of the number of men employed in iron and steel production in 1887:

	Hands.
Furnaces and rolling mills	193,000
Iron ore mining	50,600
Anthracite coal mining	10,000
Bituminous coal mining	10,000
Coking coal	3,500
Mining coal for coke	20,000
Quarrying limestone	2,000
Making charcoal	1,000
Total	290,100

Steel production.

This does not include the men employed in transportation, or in such manufactures as wire mills, pipe works, foundries, boiler shops, bridge and structural iron shops. The phenomenal growth of the manufacturing power of the United States in steel production is shown by the fact that in 1867, the first year of their production in America, the quantity of Bessemer steel rails made was 2,550 tons. The first Siemens gas furnace was erected in the same year.

United States imports from Great Britain.

The enormous production of the United States in 1887 was notably insufficient for the requirements, for in addition she imported from Great Britain as follows:

	Tons
Pig iron	403,559
Bars, angles, etc	4,273
Railway workings	182,270
Hoops, sheets, etc	32,471
Tin plates	268,364
Cast and wrought manufactures	2,925
Old iron	172,927
Steel unwrought	215,656
	1,282,445=1,436,339 tons of 2,000 lb. *

BRITAIN'S PRODUCTION.

Great Britain's production of iron and steel.

Great Britain's production in 1887 was 8,334,957 tons of 2,000 lb.; of Bessemer steel ingots, 2,312,123 tons; of open hearth steel, 1,098,836 tons, an increase in this make of steel over the preceding year of 321,388 tons; of crucible steel, 112,000 tons, the usual yearly production of steel by this process. Great Britain's production in the first half year of 1888 showed an increase in the make of pig iron of 262,850 tons, an increase in production

* Throughout these notes the ton weight is reduced to the 2,000 lb. standard.

of Bessemer steel ingots of 152,237 tons, and an increase in open hearth steel ingots of 236,354 tons, with 223 furnaces of the latter construction employed, 47 unemployed and 30 new furnaces under construction.

THE WORLD'S PRODUCTION.

The world's production of pig iron.

In 1855 the world's production of pig iron was estimated at 6,720,000 tons, of which Great Britain supplied one-half and the United States one-eighth. In 1826 the output of the British pig iron furnaces was estimated at 720,000 tons. At that time England imported yearly from Russia and Sweden 78,000 tons of iron. The operation of converting cast iron into bar iron in the puddling furnace had not been introduced. Theretofore "the operation had been effected by the agency of wood charcoal in refineries analogous to those still (1866) made use of in France. But when that kind of fuel began to be scarce it came to be mixed with coke in various proportions. The bar iron thus produced was usually hard and required much time to convert, so that an establishment which could produce 20 tons of bar iron in a week was deemed considerable. . . Till 1740 the smelting of iron ores in England was executed entirely with wood charcoal." In 1788, "53 blast furnaces fired with coke were in activity, which furnished 54,640 tons of iron in a year." The quantity of cast iron produced in the same year by means of charcoal was 14,670 tons. "In 1796 the wood charcoal process was almost entirely given up."*

SWEDEN'S IRON TRADE.

Sweden's export of pig and bar iron.

Sweden continues to export bar iron and even pig iron to Great Britain, notwithstanding the enormous expansion of the iron industry of the latter. Britain received in 1887 four-fifths of the whole Swedish pig iron export, to the amount of 44,300 tons, and nearly one-half of the bar iron export, the amount being 104,057 tons. The total Swedish export for the year was, of pig iron, 55,188 tons, of bar iron, 219,756 tons. The export of iron ore rose in the same year from 21,601 tons to 46,776 tons. "The increase in the latter article is very encouraging," says the report, "as the export of iron ore had of late years, in consequence of the competition of Spanish ores, sunk to a mere minimum. This year the exports will be much larger owing to the working of the Gellivara iron deposits. Prices have varied from 3s. 6d. to 7s. 6d. (stg.) per ton (2,240 lb.)" The average yearly output of the mines for five years, to 1886 inclusive, was 972,000 tons, employing 6,332 hands, of whom 625 were women and children. There were 164 furnaces in blast in 1886, which produced 484,000 tons of pig; 217 bar iron works, with 638 hearths, returning 259,000 tons. The make of bar iron is yearly diminishing, which, says the report, "indicates that efforts of development are directed towards the finished goods industries." There were also 33 steel works in which were made 59,000 tons of Bessemer steel, 24,360 tons of Siemens-Martin steel and 1,940 tons of other kinds of steel. In the manufacture of finished iron and steel goods there were made 14,560 tons of plates, 11,200 tons of nails, 6,720 tons of tools and implements, including agricultural, and 12,300 tons of sundry articles. New licenses were issued for the working of new iron deposits to the number of 103, for the working of old deposits re-worked to the number of 209, and 38 mines ceased to be worked. "An association formed last year called the Swedish Export association, of which the crown prince of Sweden is the president, is already doing much good, several new markets for Swedish manufactured iron and steel goods having been opened outside Europe, and this year the government has granted a sum of £1,000 towards the expenses of sending a qualified agent on a year's journey to the east and to Australia."

The ron and steel industry.

The relation of the Swedish iron trade to the old fashioned crucible steel manufacture of Sheffield is very distinctly stated by Mr. Henry Seebohm in

*Ure's Dictionary of Arts, 1866.

a paper read in 1884 before the Iron and Steel Institute of Great Britain :—"The accumulated experience of a century," he says, "has convinced the manufacturers of crucible cast steel that the finest qualities can only be made from bar steel which has been converted from iron made from Dannemora ore. This iron is expensive ; its average cost for the last forty years has been at least £25 (stg.) a ton ; the process of converting it into steel is slow and costly, the process of melting in small crucibles is extravagant, both in labor and fuel, and subsequently the best qualities of crucible cast steel can only be sold at a high price. So-called best crucible cast steel is sold at low prices by unscrupulous manufacturers and bought by credulous consumers, but though it is quite possible for high priced steel to be bad it is absolutely impossible that low priced steel can be good. The finest quantity of steel cannot be made of cheap material or by a cheap process. Every year the attempt is made, and every year it signally fails. No one ever made a better try than Sir Henry Bessemer, but his failure was as complete as that of his predecessors. He attempted to produce an article at £6 a ton to compete with one at £60 a ton, and failed absolutely. It is true that his steel was a success, perhaps the most brilliant success of the century. I am not quite sure that he himself believes in his failure. In his lecture before the Cutlers' company of London in 1880 he chaffed the steel manufacturers of Sheffield on their antiquated attachment to the rule of thumb, and twitted them with the assertion that the high price of crucible cast steel arose from a combination of trade interest on their part and of prejudice on the part of their customers. Sir Henry Bessemer may have half-ruined the wrought iron trade and revolutionised the pig iron trade, but the crucible cast steel trade holds its own in spite of his great discoveries. When railways were first introduced and waggons and coaches to a large extent driven off the road, many people thought that the price of horses would permanently fall, but exactly the contrary took place. Similar fears were entertained that the demand for crucible cast steel would seriously decline when Bessemer and Siemens steel came into the market. This has not been the case. The commoner qualities of crucible cast steel have been to a large extent suppressed by Bessemer's and Siemens' steel, but the enormous quantities made by the latter processes have required for their manipulation, directly or indirectly, such a large quantity of the better qualities of crucible cast steel that the total amount of the latter now produced in various parts of the world is probably double that which was required before the birth of its rivals."

Crucible cast steel from Dannemora iron.

High priced and low priced steel.

PRICES OF IRON.

Some recent quotations give the relative values in the United States markets of charcoal iron compared with that made with other fuel as follows : Philadelphia, Jan. 7, 1890—charcoal blooms, \$54 to \$56; run out anthracite, \$44 to 45 per "bloom" ton of 2,464 lb. Chicago—lake Superior charcoal pig, all numbers, \$23.00 to \$23.50; lake Superior coke, No. 1, \$19.50 to \$20. Cincinnati—Southern coke, No. 1, \$18.50 to \$19.00 ; Hanging Rock charcoal, No. 1, \$21.00 to \$23 ; common bar iron, \$1.90 ; charcoal bar iron, \$2.90 to \$3. Pittsburg, Pa.—No. 1 foundry, \$19.50 to \$20 ; No. 1 charcoal, foundry, \$24 to 24.50; cold blast charcoal, \$25 to \$28. New York metal prices, Oct. 3—Refined iron, round and square, \$2.20 to \$2.80 ; Norway rods, \$4 to \$5.

Quotations of charcoal, coke and anthracite pig iron.

MAGNETIC IRON ORES.

The magnetite ore from which the best brands of iron in Sweden and Norway are made is similar to the magnetite of the valleys drained by the Ottawa river and her tributary streams, and by the upper waters of the Trent and Moira. Dr. Sterry Hunt in the Geological Survey report of 1886 says : "The so-called primitive gneiss formation of Scandinavia has long been regarded by the Geological Survey as belonging to the Laurentian system, and is asso-

Magnetic ores of Sweden, Norway and Ontario.

ciated with crystalline limestones which have afforded most of the minerals that are to be met with in the Laurentian limestones of North America, together with many additional species. Such of these minerals as are common to the two regions offer close resemblances, not only in their characters and associations but also in the mode of their occurence. . . . Daubree, who in 1843 published an instructive account of his examination of the metalliferous deposits of Norway and Sweden, furnishes some interesting details of the minerals associated with the beds of magnetic iron ore in the vicinity of Arendal. The ore is here found sometimes in gneiss and at other times in a gneissoid rock, consisting of various admixtures of pyroxene, hornblende, garnet, epidote and mica, the whole associated with crystalline limestones. . . . At the iron mines in the island of Utoe, where the ore is a mixture of magnetic and specular oxides occurring in beds with hornblendic rocks passing into gneiss, or with crystalline limestone holding hornblende and mica, granitoid veinstones like those of Arendal are met with, holding orthoclase and quartz, with tourmaline and oxide of tin, together with the rare minerals, petalite, spodumene and lepidolite, which occupy the central portion of the veins. This association is the more worthy of notice as the only other known locality of the rare mineral petalite, (if we except the castor of Elba) is in the crystalline limestone of Bolton, Massachussetts, where it occurs with scapolite, hornblende, pyroxene, chrysolite, spinel, apatite and sphene, the characteristic minerals of similar limestones in Canada, New York and Scandinavia."*

Occurrence of magnetic iron ore.

Bauerman in his treatise on the metallurgy of iron, 1868, says that magnetic ores are chiefly confined to the older crystalline rocks of Scandinavia and North America, and appear under two principal conditions, either interstratified in irregular beds or tabular masses in hornblendic and chloritic schists and crystalline limestones, or irregular ramifying veins and masses in dioritic or doleritic rocks. "Iron pyrites," he says, "may be either disseminated in considerable quantity through the ore, which in such case it generally renders useless, or interspersed in small patches in the neighborhood of veins of intrusive rock such as granite. Sometimes the centre of a rock may be pure magnetite, passing at either side into copper and iron pyrites. The texture of massive magnetite appears to vary with the containing rock ; the most compact having sometimes a nearly conchoidal fracture we found in talcose schist, while the more granular and crystalline conditions prevail in hornblendic gneiss and crystalline limestones." Prof. Dana in his Manual of Geology says: "In Canada, at Baie St. Paul, there is a bed of titanic iron 90 feet wide, exposed for 200 or 300 feet, occurring in syenite with rutile or oxide of titanium. The ore does not differ from ordinary specular iron in appearance, but the powder is not red. In Sweden and Norway the iron ores are interstratified in the same manner with crystalline rocks,—mainly gneiss, hornblende rocks, talcose and chloritic schists, argillaceous schists, quartzite and granular limestone, with which they are more or less laminated. At Dannemora the stratum containing iron is 600 feet in width, and it occurs with granular limestone, talcose and chloritic schists and gneiss. At Utoe, Sweden, red jaspery quartz bands the ore in the same way as in Michigan ; the ore—the specular mixed with the magnetic—occurs in mica schist and quartzite in an irregularly shaped mass about 120 feet in its widest part. At Gellivara there is an iron mountain three or four miles long and one-and-a-half wide, consisting mostly of magnetic ore, with some specular ore. In each of these regions the beds dip with the enclosing rock, showing that all has had a common history."†

The magnetic ores of the primitive geological formation have peculiar characters which impart the highest value for the manufacture of strong

* Geological Survey report, 1866, pp. 194-5. † Dana's Manual of Geology, p. 140.

fibrous iron and edge tool steel. But these ores are not of uniform purity. Even the famous Dannemora ore is said to have "a small trace of iron pyrites." In the Gellivara ore mountain phosphate of lime is present in the largest one, 200 feet-bed, through about 80 feet of its thickness, the remaining 120 feet being of good quality. Iron pyrites in small quantities at least is not uncommon in the magnetic ores of southern Sweden, especially in the neighborhood of granite veins.* Nature of magnetic ores.

QUALITIES OF ORES AND METALS.

According to Chenot, the inventor of a steel making process, "the nature of the ore has much more to do with the quality of the metal (steel) than the mode of treatment, and he compares the different steels to the wines of different localities, which owe their varied qualities far more to the nature of the grapes than to any variations in the mode of their fermentation. The process of cementation employed by Chenot furnishes according to his view an exact measure of the capability of the iron to produce steel. The sponges of the iron from Sweden and the Ural mountains, after taking up six per cent. of carbon, yield a metal which is still malleable, while that of Elba with four per cent. becomes brittle and approaches to cast iron in its properties. While the ores of Sweden and the Urals are famous for the excellent quality of their steel, the ore of Elba is known to yield a very superior iron, but to be unfit for the fabrication of steel."† The American manufacturer recognises this as fully as his British rival. In Jeans' history of the American steel trade, describing the Pittsburg steel works, he says: "The firm make cast and German plow steel, all kinds of the highest class edge tool steel, etc. None but the finest grades of Swedish, Norwegian and American iron are used. The Pittsburg steel works are among the largest in the country, their annual product amounting to about 6,000 tons of finished steel of all descriptions, of an approximate value of $1,500,000. The works give employment to 350 men, whose pay-roll amounts to $250,000 a year."‡ The market quotations confirm what has been advanced respecting the importance of selecting the best ores in order to obtain the highest standard of production and price. The British quotation for cast steel for edge tools was on 2nd November, 1888, £40 to £60 stg. per ton; the American quotation of the month previous, 8½c. per ℔. At the same dates Bessemer and Siemens steels were quoted in Britain at £6 10s. to £10 the ton; in the United States at 2¾c. to 5c. per ℔. This country in the fiscal year 1886-7 imported direct from Norway and Sweden 11,017 cwt. of bar iron, entered for duty at a valuation of $2.25 per cwt., while the average value of British bar iron appears to have been less than $1.25 per cwt. Other important results are the great uniformity of price of the high-class article and the widening character of the demand for it. A late Sheffield report (Iron, Nov. 23rd, 1888,) says: "In steel castings the industry is growing rapidly, to the detriment of the iron founders. In all classes of machine work, whenever practicable, steel castings are being substituted for iron. In crucible cast steel there is also a brisker tone noticeable, home, continental and American customers buying freely, but there is little alteration in prices, the standards of the old makers, both in price and quality, only being varied under very exceptional circumstances." High-class steel.

FOUNDRY IRON FROM MAGNETIC ORES.

Not only is it the case that by proper selection of ore and careful metallurgy the highest priced product in refined iron may be made from magnetic ores, but it is also plain that any effort to make foundry iron from these ores alone will be attended with difficulty,—very great difficulty with any other fuel than charcoal. Touching the question proposed for discussion, "Why is

* Bauerman's Metallurgy of Iron, p. 67.

† Sterry Hunt in the Geological Survey report, 1853-6, p. 402.

‡ Steel, its History, Manufacture and Uses, by J. S. Jeans, 1880.

Difficulty of making foundry iron from a burden of all magnetites.

it difficult to make good foundry pig iron from a burden of all magnetites?" Mr. Cook, manager of the Warwick Iron company, in a recent number of the Journal of the Charcoal Iron Workers, gives his views thus: "The difficulty of producing a large percentage of foundry iron with magnetic ores was more marked with the small anthracite furnaces of former years than with the larger and better equipped plants of modern construction. The use of a portion of coke has made the management also somewhat easier, and consequently enabled the percentage of foundry iron produced to be increased. Within certain limits the greater the ease with which the iron of an ore parts with its oxygen the more regularly and rapidly will the furnace perform its work of reduction and melting, and the hotter will be the crucible with the same weight of fuel. That the reduction of magnetic ores proceeds more slowly than brown hematites or red oxides is probably due as much to their mechanical structure as to any difference in mechanical composition. Most of the magnetic ores available in the Schuylkill and Lehigh valley districts of Pennsylvania are dense, close, compound ores. These, even when entirely full of sulphur, are more or less difficult to work, especially when filled into the furnace in large pieces or masses too heavy for one man to lift into a charging barrow. The writer has seen the dense New Jersey magnetites so filled into furnaces, and at the same time the managers were complaining of the impossibility of making foundry grades and the tendency of the furnace to work irregularly, or to run off on white iron, without (to them) any apparent cause. The furnace gases experience more or less difficulty in penetrating, breaking up and deoxidising dense ores; they can be broken down more cheaply with hammers. Open, porous ores, or ores containing considerable combined water, are quickly and thoroughly permeated. In consequence, with magnetites there is a greater consumption of heat in the lower part of the furnace, and from the presence of ore only partially reduced there is apt to be sudden variations in the temperature of the crucible. One of the conditions requisite to the production of a large proportion of the higher grades of foundry iron is almost absolute uniformity of temperature of the lower parts of the furnace. . . . With magnetites forming the burden, the rapidity of travel of the stock in the furnace needs to be very carefully watched, and the composition of the slag kept as uniform as possible. Any variation in slag, or too rapid or too slow driving,—variations that would pass unnoticed with easily reducible ores,—are reasonably sure to produce marked changes in the furnace running on dense magnetites. Soft, earthy magnetic ores, on the other hand, usually carry considerable sulphur, an element which is well known as an unrelenting enemy of foundry iron. When present in the dense mass of magnetic ores it entirely unfits them for the economical production of foundry iron. When thoroughly washed however these form fairly good mixtures, as the washing not only removes the sulphur but also opens the structure of the ores, rendering them porous and easily attacked by the blast furnace gases. Brown hematites and red oxides rarely carry sulphur to any considerable extent, which alone is a decided advantage in their favor in competition with magnetic ores. . . . Low silicon in the pig iron is undesirable for foundry grades, yet for mill iron this quality becomes desirable. . . . As a rule the gangue of magnetic ores contains but little free quartz or sand; the silicon is usually in combination with lime or magnesia, and the slag to this extent is partially made, so that the limestone flux added to the ore charge to produce slag of certain composition combines with the gangue of the ore more readily and at lower temperatures than when the gangue is chiefly quartz and sand. In consequence the iron made is less liable to contain reduced silica. The silicon foundry irons made from magnetic ores give varying results in the foundry, depending on the knowledge of foremen of the melting departments."*

* Journal of the Charcoal Iron Workers, vol. VIII, pp. 21-24.

PREPARATION OF ORES FOR THE FURNACE.

Breaking, washing and roasting ores for the furnace.

The preparation of the ore by roasting, breaking, and in some cases washing, is followed where charcoal fuel is used and the most successful results attained. Ure (supplement to Dictionary of Arts, Manufactures and Mines, Am. ed. 1866) says: "The modern processes of iron smelting differ materially according as the fuel employed is charcoal or pitcoal. As an illustration of the method adopted when the former is used, the following details of the manufacture of the celebrated Oeregrund iron may be taken, premising that the operations vary in a few particulars in other countries where different kinds of ore are dealt with. The Oeregrund iron is made from the magnetic ironstone at Dannemora in Sweden. The ore in moderately large piles, such as it comes from the mine, is first roasted. For this purpose an oblong coffer of masonry, 18 feet long, 15 feet wide and about 6 feet in depth, open at top and furnished with a door, is entirely filled with logs of wood; over this the ore is piled to the height of from 5 to 7 feet, and is covered with a coating of small charcoal, almost a foot and a half in thickness. Fire is then communicated to the bottom of the pile by means of the door just mentioned, and in a short time the combustion spreads through the whole mass; the small quantity of pyrites that the ore contains is decomposed by the volatilisation of the sulphur; the moisture is also driven off, and the ore from being very hard and refractory becomes very easily pulverisable. In the space of 24 hours roasting is completed, and the ore when sufficiently cool is transferred to a stamping mill where it is pounded dry and sifted through a network of iron, which will not let any piece larger than a hazel nut to pass. It is now ready to be smelted." M. Gautier in his Dictionary, vol. 4, describes Jacob's process for the washing and calcination of phosphorised ores, and says in conclusion: "Such calcination and washing is advantageous, independently of its effect in removing phosphorus, as it gets rid of much of the sulphur, and so admits of producing a softer and grayer pig-iron. . . Roasting is always applied to oxidise iron ores in order to obtain the highest degree of oxidation. A simple oxidation is performed when magnetic ores are exposed to heat and air and transferred into peroxide." Describing the American method Overman says (p. 486): "The operation is performed in the open air in heaps, and as most roast ovens have been abandoned we suppose this method is preferable to that in ovens. At the same conclusion we arrive equally as well by deductions based on the nature of the mineral and the end to be accomplished. Magnetic ore should be roasted if it is desirable to melt carburetted iron, for this ore is too compact to admit of the absorption of carbon, and it must be made porous in order to form gray iron. It contains also very frequently iron pyrites, blende, galena, arseniuret, silica and other substances which it is necessary to oxidise. When specular iron contains pyrites, which frequently happens, it must be roasted. Sparry ore is to be roasted to remove carbonic acid. If these ores are pure, that is, free from sulphurets, a strong and rapid heat can be made; but when they are impure a red heat with a liberal supply of air and moisture are requisite to succeed well. . . Half the fuel used in heaps may be saved by roasting in ovens. A ton of coal or a cord of wood will afford heat for twenty tons of ore when roasted in large piles or heaps. In an oven one-half, and in a well constructed oven one-third of that fuel is sufficient to accomplish the work, and if the labor is considered equal in both places, which is in reality in favor of the oven, the advantages of the latter are evident. Where the quality of stone coal as it respects sulphur is doubtful, wood ought to be used in roasting, for the affinity of iron for sulphur is so great that it will absorb any which is not oxidised. In using the kiln for roasting it is not advisable to mix ore and coal, because if the coal contains sulphur it will certainly adhere to the iron. . . Some ore may be roasted in forty-eight hours, but it would be better if twice the time were occupied for it. When good iron is to be made the ore is riddled.

Charcoal and mineral coal as fuel for roasting.

Smelting in the Catalan forge.

Dry fine ore will trickle through the space between the coal in the blast furnace and arrive unprepared in the hearth, causing white-iron, and often serious disturbances in the smelting operation, by producing a raw slag or by accumulating in certain parts of the furnace and obstructing the blast, thus causing scaffolding. In the Catalan forge process, (says Prof. Huntington) the ore is crushed by the hammer and divided by sifting into lumps and very coarse powder. In the one part of the forge only charcoal and powder are introduced and in the other only lumps of ore. That the ore should be in lumps at that part is a very important point, for in this way the hot reducing gas, carbonic oxide, generated by the action of the blast on the charcoal, is able to pass freely through the mass of the ore, the effect of which is that the water of hydration and the moisture are first driven out by heat, and then the ore having become easily permeable the carbonic oxide reduces it to metallic iron." In this method the processes of roasting and reduction are simultaneously carried on. "In the American bloomary process as carried on in New Jersey and northern New York," Dr. Egleston says, "the ore must be calcined, crushed and dressed; all of it is therefore in a fine state of division, in grains not larger than one-tenth of an inch in diameter. . . . The impurities contained in the ore are mostly removed by dressing; what remains is removed in the process by the formation of silicate of iron. . . . With a view to making the ore friable, it is usually calcined before crushing in kilns containing about 300 tons, which are roasted in three to six days with a consumption of about 25 cords of wood per kiln. Crushing and dressing often conducted in a crude, primitive fashion, follow for preparing the ore previous to its reduction in the blowing forge." The ore for use in the Siemens direct process is also reduced to the size of pease or beans.

Mechanical treatment of magnetic ores

The magnetites of the Adirondack hills are for the most part high in silicon, with mere traces of sulphur and phosphorus, but in some instances an objectionable quantity of the latter. Roasting appears to have been followed some years ago to aid in the disintegration of the ore rather than for its chemical results, although it would seem judicious to return to the discarded practice with the help of modern improvements. The introduction of well-planned crushing and separating mills has no doubt led to the change. In these mills the ore is received from railway cars dumping on an inclined table, from which it passes through spouts 13 by 15 inches to Blake crushing and pulverising rolls. A graduating cone permits the discharge of stuff sized for passage to the separator screens, and returns ore too large to an elevator for another passage through the rolls. From the screens the stuff passing over is returned for treatment, while that going through is discharged on the washing jigs. These are sieves placed in tanks of water, to which a set of plungers impart the jigging motion necessary to the separation of ore from rock according to their respective gravities. A layer of ore of the size of filberts "is deposited on the sieves, which has the effect of allowing particles of the same specific gravity as itself to pass through it and the sieve, while it keeps back any particles of less specific gravity, which last are gradually washed over the end from one compartment into the next lower one, the light waste from the last compartment finally passing away." A separator of this description at Ironville, Essex county, N. Y., driven by water power of 40 h. p. effect, is capable of treating five tons an hour. After the descent of the ore from the car two top-men are required at the spout and one man at the jig at the conclusion of the process. The daily wages are for the first \$1.10 each, and for the jigman who looks to the working of the machinery and is handy at repairs, \$1.50. The current labor expense is therefore light, but the charge for breakage has been a variable quantity. In 1882 the repair charges against 3,452 tons crushed and separated were \$1.83 a ton, and in 1883 for 3,381 tons, \$1.23½

Cost of treatment.

a ton. The manager made some improvements in the machinery in 1884, which largely reduced expenses, the amount being only $22\frac{1}{8}$ cents per ton for 3,181 tons, in 1885 at the rate of $81\frac{1}{8}$ cents for 927 tons, and in 1887 at the rate of 17 cents for 2,174 tons. In 1886 only 183 tons were dressed, against which the repair charges were $\$2.46\frac{1}{4}$ a ton. The dressed ore is loaded on cars by laborers at an expense of seven cents a ton. An immense mill, said to be the best in the United States, is in operation at Lyon mountain. The machinery is essentially the same as in the smaller mill at Ironville, with the exception of the jigs, which are more elaborate in construction and better adapted for dealing with large quantities of ore. The mill is driven with a daily consumption of nine tons of anthracite pea coal by a 250 h. p. engine. There are ten laborers, engineer, two firemen and mill manager. The present daily working is 250 tons, capable of being pushed to 500 tons. Here also the repairs account is the principal item. But the end attained leaves nothing to be desired so far as the crushing of the ore and separation from rocky matter are concerned. The ore is delivered in the size of coarse Liverpool salt, carrying about 5 per cent. of water and about 5 per cent. of silicious dust. The tailings are discharged by a flume, and the loss of ore apparent from their examination is insignificant. To an onlooker the cost of repairs would seem to be in some degree preventible by more careful attention to the material in the machinery and more cost for watchful superintendence. Electric separation by bringing a stream of crushed ore within the "field" of rotating magnets is likely to supersede the jiggers, and for titaniferous ores is certainly preferable. It remains to be proved whether the washing process does not aid in the removal of some pyritous matter as well as assist in its diminution in the bloomary. Edison's magnetic separator has been tested upon the ores belonging to Witherbees, Sherman & Co. of Port Henry, N. Y. "The object of the separation would be to remove the silica, which is present in so large a quantity as to prevent the advantageous shipment of the ore to the furnaces. The analyses show that the result is satisfactory." There are also some Canadian patents for separators of this class. In fact the absolute separation of gangue, if attainable by the electric separator, is not desirable in ore destined for the Catalan forge, a certain amount of slag being required for the protection of the metal from excessive oxidation in the open charcoal fire. The preference for one or the other process should rest on a careful estimate of the merits of each, the character of the ore and its destination, whether for the blast furnace, forge or open hearth furnace. What has been stated regarding repairs does not apply to that part of the process where the electric separator comes into competition with the jig. It is in the heavy machinery that the breaks occur. The expense of the jigs is insignificant. The cost of crushing, separating, with interest on capital, maintenance of mill and repairs, in a good business will not exceed 75 cents a ton.

Electric separation.

"As characteristic of the Swedish pig-iron manufacture," says Prof. Akerman, "there deserves to be mentioned the strong calcining of the ores in the Westman gas-furnace and that the calcined ores before being charged into the blast furnace are crushed between rolls or Blake crushers to the size of a walnut or under." The treatment of ore to the extent it is conducted in the American crushing mill is therefore required in the interest of the mine owner and in the Catalan process. To the former it affords the means of saving a large quantity of material brought to the surface, of equal cost to raise it with the richest ore, but which from its intermixture with rock will not pay for transportation.

Economy of crushing and roasting.

"The best spent wages I ever paid," said an Ohio charcoal furnace master, "was to a strong able-bodied man to break up the ores before calcining them into pieces as big as your fist. Then I sifted braize through it and burned it

well." For desulphurising fine ore there is no gas kiln in use. The kiln must occupy an intermediate place between the Blake crusher and the pulveriser. It is claimed for the Taylor kiln that it can desulphurise from 5 to 10 per cent. of fine ore, about the quantity which will pass from the jaws of the crusher working on a dense ore.*

REQUIREMENTS OF A ROASTING KILN.

Rosting kilns for magnetic ores.

"In charcoal blooms a quantity of sulphur so small as 0.035 per cent. is sufficient to produce cracks in the bar-iron rolled from them." In the blast furnace sulphur is a source of loss from the necessity of melting a large amount of limestone for producing a slag for its removal. In eastern Pennsylvania the stone burden rises to 50 and 60 per cent. of the ore, while with lake Superior ore very little troubled with sulphur there is required only 15 per cent. limestone for making a basic slag. "As no steel making process is able to remove sulphur, steel makers are obliged to mix native red-short pig with imported pig iron in the cupolas and in the open hearth furnaces, and to mix native red-short ores with imported ores in the blast furnaces. . . The price of imported Cumberland pig iron for steel making with about 0.025 sulphur is about $2 higher, and that of purest Swedish pig iron, of about 0.015 per cent. sulphur, $7 higher than the native red-short pig at the same works. . . . "To effect a clean roasting, reducing the sulphur to less than one-half, there is indeed no other way than the use of gas. . . . The fuel for gas producing ought to be refuse, unfit for carrying into the blast furnace."† Refuse from wood, other than sawdust, ought to be burned in a shaft. In Sweden an invention is successfully in operation for reducing the moisture in gases from 50 to 2 per cent., which ought to be of value in forest districts. The surplus gas from the furnace cannot always be counted on. Every fit of indigestion in the blast furnace is followed by a lowering of the heating power of the waste gases, and it is just on such an occasion that the most completely roasted ore is required. The Swedish Westman kiln and Dillner kiln divide with the American Taylor kiln the commendations of Mr. Lilienberg, an authority on the subject. The last named is the least expensive kiln, and its capacity for reducing the sulphur in the very sulphurous magnetic ores of New Jersey has been successfully demonstrated. Whether the like result is attainable with less sulphurous ores such as those of eastern Ontario is not to be inferred without trial. The facility with which any ore will part with sulphur depends upon its density, crystalline texture and the mineral character of the pyrites. Summing up the requirements of a roasting kiln, they seem to be as follows: (1) The sulphur shall be reduced by single roasting from 3 to 4 down to 0.10 per cent. (2) Fine ore and lumps have to be roasted together as they come from the mines, without any extra expense for separation. (3) The cost of a kiln roasting 50 tons of ore a day shall not exceed $2,000, which of course ought to stand in some proportion to the price of the ore. (4) The cost of roasting shall not exceed 25 cents a ton. (5) The height shall not be greater than the space below the track in the stock-house, or about 12 feet, in order that elevators may be avoided and hopper cars used for direct unloading."‡ Such are the tests to be applied in estimating the qualities of a kiln, in the opinion of Mr.

* In the Taylor kiln with its short space above and the long space below the gas inlet, sulphur is generally reduced from 2 to 5 per cent. down to 0.25 per cent., sometimes to 0.10 per cent. The cost of erection is $1,800 to $2,000, or about one-fourth of that of the Westman kiln. The height for lifting the ore is about the same. The consumption of coal, which is an important item where the waste gases from the blast furnace cannot be used, is reported to me so low as 1 cwt. lump anthracite per ton of ore.—Journal of the Charcoal Iron Workers, vol. III, p. 264.

† N. Lilienberg, in the Charcoal Iron Workers' Journal, vol. III, pp. 261-263.

‡ Journal of the Charcoal Iron Workers, vol. III., p. 265.

Lilienberg, but it may be remarked that the charge for roasting is too low in view of the fact that any process for desulphurising in the furnace will cost very much more.

PREPARATION OF FLUX.

The breaking and calcination of limestones and dolomites for use as flux in the blast furnace has been attended with variable results, those adverse to the practice being probably due to the mixture of dust with the charge. The equal descent of ore, flux and fuel is necessary to the successful operation of the furnace, and obviously this cannot be attained where there is much diversity of size in the materials. The evil shows itself in the agglutinatian of some of the materials before reduction, followed by explosions, the formation of "scaffolds" and irregularity in the character of the iron. Keeping in view the management of the charge so as to avoid this evil, it is apparent that calcination or the separation of carbonic acid from limestone and the more refractory magnesian limestone or dolomite increases their chemical activity of combination with sulphur and phosphorous within the furnace, and by promoting economy of fuel in their reduction admits of increasing the proportional burden of ore. "The crystalline limestones of the Laurentian series," says Logan, "are remarkable for the variety of crystalline minerals which they contain," which renders their careful analysis before use in the blast furnace a matter of necessity. The coarse crystalline dolomites contain from 45 to 58 per cent. carbonate of lime, 34 to 46 per cent. carbonate of magnesia, with oxide of iron and quartz.

Treatment of flux.

SUPERIOR QUALITY OF CHARCOAL IRON.

"The best and second marks of Dannemora iron owe their superiority over other Swedish irons to greater freedom from the contamination of foreign substances. Both these irons and the marks made from hematites are superior to the British for steel purposes, because both are made with charcoal only. Even Swedish blooms which have been heated and welded in our coke fires and drawn into bars are found to be deteriorated thereby. . . . The consumption of charcoal varies with the nature of the ore, the average for the whole country (Sweden) being from 16 to 17 cwt. (112lb.) per ton of white or mottled forge pig, and about one-third more, or from 21 to 22 cwt. per ton of gray metal suitable for foundry or Bessemer steel purposes. At Langshytta the consumption is as low as $13\frac{1}{2}$ to 14 cwt., making white and mottled iron. The poor ores of Talberg require as much as 50 or 60 cwt. per ton . . . At Greenwood furnace, near Marquette, on lake Superior, the fuel is hardwood, principally maple charcoal, the consumption being at the rate of 125 bushels, weighing from 16 to 20 lb. each, or about 25 cwt. per ton of pig iron. The ores are not roasted. . . . At the Wyandotte iron works near Detroit the consumption of light wood coal is 140 bushels of 14 lb. weight each per ton."* In Greenwood's treatise on Steel and Iron, 1884, it is stated that "the Canadian charcoal furnaces making dark gray pig iron require from $15\frac{1}{2}$ to 23 cwt. of charcoal per ton of iron made. It is noticeable from these last figures that the consumption of charcoal in charcoal furnaces is much less per ton of metal produced than is the consumption of coke in coke furnaces, and that a greater amount of work is thus performed by the fuel in the latter than in the former, owing probably to the greater amount of flux and earthy matters that have to be converted into slag in the coke furnace than in the charcoal furnace using purer ores." While the information on which the statement is based may be questioned, the inference is theoretically correct. One part by weight of charcoal is to an equal weight of stone coal as 75 to 60 for raising equal weights of water from 32° to 212°, according to

Charcoal and coke for furnace fuel.

*Bauerman on the Metallurgy of Iron, p. 205.

Voerman. Ure (Dictionary of Arts, Manufactures and Mines, vol. II, 1878), gives the following table:

Species of combustible.	Pounds of water which 1 lb. fuel can heat from 0° to 212°	Pounds of boiling water evaporated by 1 lb. fuel.
Wood charcoal	73.00	13.27
Turf charcoal	64.00	11.63
Coke	65.00	11.81
Pitcoal	60.00	10.90
Sulphuretted hydrogen gas	75.00	13.81
Oil. Wax. Tallow.	78.00	14.18

Charcoal fuel for the bloomary process.

In the American bloomary process "none of the dense fuels such as coke or anthracite would be used, as they would require a greater pressure of blast and give a higher temperature, the result of which would probably be an impure cast iron. . . . To perform the operation of reduction only a high temperature is not necessary, but as the reduced iron is in grains of the form of the fine ore the temperature of low welding heat is necessary to bind the particles together. Any temperature higher than this is likely to introduce impurities, notably carbon, which will make the iron hard and sticky, or may even produce cast iron. This is the reason why soft wood charcoal is so much more preferable in this process than that made from denser woods which would give too high a temperature. . . . There are besides some ores of iron of exceptional purity, but so lean that they can hardly be worked in the blast furnace. To be worked at all they must be crushed and dressed, and it is only practicable to treat the fine ore thus produced in a bloomary with charcoal."* Since Dr. Egleston's paper was written the partial use of fine ore in the blast furnace has become widely extended, the quantity allowed in the charge being as much as 15 to 20 per cent. Dressed fine ore is also essential to the oxidising process for the removal of phosphorus in the rotating furnace. Dr. Egleston further says that "the kiln has a peculiar importance in the vicinity of concentration works, as it gives a charcoal free from dirt, a very important consideration, as the whole object of dressing the ores is to get rid of the silica, and if dirt were introduced in the fuel the loss of iron would not only be increased but the benefit derived from dressing the ores very much diminished. . . . At the Norton iron works, Plattsburgh, N.Y., the charcoal for the blast furnace and for kindling fires is made of slabs, butt ends of logs and floodwood."

RETORT AND PIT CHARCOAL.

Processes of making charcoal.

The controversy between the advocates of the respective merits of retort and pit charcoal has brought out pretty clearly that under skilful management and favorable circumstances the old fashioned process is scarcely less effective than the use of the retort. Instances are recorded were 59 and 60 bushels to the cord of soft wood have been obtained in Swedish meilers. It is claimed that in the retorts of Mathieu, coaling one cord charges, 64 to 70 bushels have been produced, the average results of several operations being stated at 1,450 lb. of charcoal per cord of hard wood. The Swedish coal burners claim for their kilns a production of 62 bushels per cord from poor wood, and 66.7 bushels from good dry wood. The general average of American kilns is considerably less. At the kilns of the J. & J. Rogers Iron Co.

*Dr. Egleston in the Transactions of the American Institute of Mining Engineers, 1879.

the usual yield is 50 bushels of 2,748 cubic inches per cord of first growth, mixed hard and soft woods, and 40 to 45 bushels per cord of second growth woods. The labor cost of burning at the Chateaugay Ore and Iron company's kilns by piece work is \$1.12½ cents per 100 bushels. The cost of manufacture in north-eastern New York is varied only by transportation charges, being generally constant at the rate of 6 to 6½ cents a bushel, made up as follows:

Cost of production.

Cutting and hauling wood to kilns, per cord	\$1 50
Coaling and incidentals, average per cord	63
Hauling produce of one cord to forges	62
Cost of manufacturing one cord—50 bushels @ 5½ cts.	\$2 75

Stumpage per cord 25 to 50 cts.—½ to 1 cent per bushel.

BY-PRODUCTS OF CHARCOAL FURNACES.

The manufacture of acetate of lime as a by-product was carried on by the J. & J. Rogers Iron Co., but not being a commercial success it was abandoned. No wood alcohol was saved. The results of the operation of the Mathieu wood-carbonising and distilling plant at Port Leyden do not appear to have warranted the claims of the inventor, which as stated at a meeting of the United States Charcoal Iron Association were, that the Luther Manufacturing company obtained 70 bushels of charcoal, 4½ gallons of methylic spirit and 125 lb. acetate of lime per cord of wood; that at Shelby, Ababama, from 100 cords of pine wood were obtained 6,460 bushels of charcoal, 1,013 gallons of crude turpentine, 900 gallons of tar; that at St. Ignace, Michigan, 18 men operated 56 one-cord retorts at an expense of \$24 a day, producing 3,840 bushels charcoal, 180 gallons methylic acid worth 70 cents a gallon, and 9,000 lb. acetate of lime worth 2¼ cents a pound. The plant was estimated to cost \$366 a cord of wood, its production to be worth \$6 and the expenses to be 60 cents a cord of wood. The system of Dr. Pierce is less costly than that of Mathieu. The latter requires the wood to be cut in stove lengths and charged in a retort set in fire brick. The wood is completely carbonised in less than 24 hours. The process of Pierce makes the kiln essentially a retort heated by a furnace on the outside. Cordwood is charged in the usual way in a bee-hive kiln, and the vapors for distillation are conducted in mains to an adjacent still-house. This is the system in use at Deseronto, the success of which is in marked contrast with the failure of the Mathieu process works at Sharbot lake. It should be borne in mind that the multiplication of wood chemical stills ceases to be lucrative when the production of acetates exceeds the demand. The manufacture of acetic acid has not yet been attempted. The importation amounts to 25,000 gallons a year of the import value of 80 cents per gallon. The production of gas from the vapors of the charcoal kiln, condensable as well as uncondensable, for steel or puddling furnaces will afford when these volatile products are exposed to high temperatures—

The Mathieu and Pierce methods of manufacture.

Carbon dioxide	18 to 25
Carbon oxide	40 to 50
Hydrogen	14 to 17
Marsh gas	8 to 12
Olefiant gas	6 to 7

A considerable portion of the gas generated in one or more kilns can be employed in carbonising the wood in other kilns. In a well reduced kiln carbonisation is effected by the burning of the wood gases instead of the wood itself. Only a small amount of wood ashes is found, and that directly under the opening through which the charge was first fired. Whenever wood ashes are found in different parts of the kiln the collier takes them as evidence of an unsuccessfully reduced kiln and of a corresponding waste. More conclusive evidence that the gases chiefly furnish the combustible for charring

Wood gases and acids.

wood is found in the fact that if the gases are captured as they are thrown off or as they issue from the kiln and condensed, less than one-half of the acetic acid, wood alcohol and tarry compounds that the wood was capable of generating is obtained. By condensing the gases from a kiln reduced in the ordinary manner and under favorable circumstances never more than one hundred and twenty pounds of acetate of lime and one and a half gallons of wood alcohol per cord are obtained, whereas the amount of acetate of lime per cord should be four hundred pounds and of alcohol from three to five gallons. The condensation of the issuing gases shows an excess of water, to be accounted for only on the supposed combustion of large portions of gases in the kiln. Again, there is found among the gases thrown off but little carbonic acid gas.* The variety of analyses of gas products given and the discrepancy in the statements of condensable products are due no doubt to the variable character of the wood experimented upon and to the rate of driving the kiln, that is, the degree of temperature at which the products are withdrawn. The products of wood carbonised at temperatures between 150° and 1,100° Cent. are:

At	Carbon.	Hydrogen.	Oxygen, nitrogen and loss.	Carbon for given weight of wood.
150°	47.51	6.12	46.29	47.51
250	65.59	4.81	28.97	32.98
350	76.64	4.14	18.44	22.42
1,100	83.29	1.70	13.79	15.32

"The lower the temperature and the longer the time taken to reach the point of carbonisation, the greater will be the yield of charcoal." This statement holds good of the ordinary wood fired kilns, and is in a measure true of retorts, but it is evident that in the gas-firing or, more properly, gas-carbonising processes of Pierce and Mathieu there is no comparison between the time required for their operation and that of the common kiln or the meiler. The superiority of the gas-carbonising process appears when it is shown that in coaling in heaps one-third of the wood is required for the work of carbonisation.

PROPERTIES OF CHARCOAL FUEL.

Some of the properties of charcoal fuel, upon which depend its great superiority for metallurgical purposes, are:

1. Its chemical composition, as follows:

Chemical composition.

	Beechwood charcoal from pile.	Light charcoal from wood gas works.
Carbon	85.89	87.43
Hydrogen	2.41	2.26
Oxygen and nitrogen	1.45	0.54
Ash	3.02	1.56
Water	7.23	8.21

In one cubic foot of charcoal weighing $15\frac{1}{2}$ lb. may be stored without mechanical compression a little over 9 cubic feet of oxygen, representing a mechanical pressure of 126 lb. to the square inch. Blocks of fine boxwood charcoal absorbed gases in the following proportion:

	Volumes.		Volumes.
Ammonia	90	Carbonic oxide	9.42
Hydrochloric acid gas.	85	Oxygen	9.25
Sulphurous acid	65	Nitrogen	6.50
Sulphuretted hydrogen.	55	Carbonated hydrogen	5.00
Carbonic acid	35	Hydrogen	1.75

* See Dr. H. M. Pierce in the Charcoal Iron Workers Journal, vol. IV, p. 254.

The absorbent property of charcoal is due to catalysis, that is, it is of the same character as the absorbent power of spongy platinum. At a white heat it deoxidises potassia, soda and phosphoric acid, setting free in vapor potassium, sodium and phosphorus. At a full red heat it converts most of the sulphates and sulphides and decomposes water. The ash consists of carbonate of potash, silica, carbonate of lime, ferrous oxide and a small fraction of phosphorus, comparing with anthracite and coke as to this last constituent as follows :

	per cent.
Phosphorus in charcoal	.011
" in anthracite	.018
" Connellsville coke	.029

In a table of analysis of Pennsylvania cokes, the phosphorus varies from a trace to .2438 per cent.

2. Its calorific and chemical activity. Charcoal fuel is more oxidised and the ore more deoxidised in the presence of charcoal at the top of the furnace than is the case with coke or any other fuel, and this is due to the more ready action of carbonic acid on charcoal in forming carbonic oxide than happens with coke. The larger amount of alkalies in charcoal also favors the development of cyanides, which probably contribute to the rapid reduction effected by charcoal relatively to the weight of fuel. Charcoal furnaces usually make more pig for a given cubic capacity than when coke or anthracite is employed. Thus while some Styrian charcoal furnaces have been made to produce for every 1,000 cubic feet of capacity from 110 to 120 tons weekly —the capacity varying from 500 to 1,200 cubic feet—and while the Swedish and some American charcoal furnaces of 1,000 to 3,000 cubic feet capacity produce 50 to 70 tons weekly per 1,000 feet, the large English coke blast furnaces of 15,000 to 20,000 cubic feet and upwards usually produce only 15 to 30 tons weekly per 1,000 feet. With charcoal it does not appear that an increased rate of driving the furnace by putting on more blast necessarily causes an increase in the fuel consumption, the cause being the relatively smaller loss of heat by radiation. Sir I. Lowthian Bell in a paper presented to the Iron and Steel Institute of Great Britain says: "Ironmasters of the Vordernberg valley do not possess the means of presenting for our inspection blast furnaces of the colossal dimensions of the modern class or of showing our appliances for heating the blast up to 1,500° to 1,600° F. (865° to 920° C). We shall nevertheless enjoy the opportunity of seeing iron made with what at first sight may appear an almost incredibly small quantity of fuel in furnaces containing only about 2,250 cubic feet and blown with air at 392° F. (200° C). I would only remind you of the costly plant by which we have been able in Great Britain to bring down our consumption to something like one ton of coke per ton of metal. Furnaces of 12,000 to 40,000 cubic feet have been erected and heaters are employed which from their construction and size raise the temperature of blast pipes to a red heat. In Styria and Carinthia you will find pig iron made with 12 to 15 cwt. of charcoal per ton, notwithstanding the smallness of the plant and the comparatively moderate temperature of the blast employed." The paper proceeds to deduce an equal amount of work for the English coke furnaces taking into account the refractory character of Cleveland ores, but establishes for the charcoal furnace an economic value second to no other.

Calorific and chemical activity of charcoal fuel.

WOOD REFUSE UTILISED IN IRON WORKS.

In the Swedish charcoal iron and steel manufacture it is not uncommon to find the works operated in connection with sawmills. At the Domnarfvet iron works the power is obtained from the river Dal Elf, where the company operate sawmills which use up 400,000 to 500,000 logs per year. The slabs and refuse are utilised to make a large proportion of the charcoal for the blast furnaces and the sawdust is used to produce gas for the regenerative furnaces.

Operating iron furnaces in connection with sawmills in Sweden.

The immense water power is utilised by nine turbines, the duty of which is estimated to yield only 55 per cent. of the theoretical maximum. Two 400 h. p. turbines drive the Bessemer blower engines, two 100 h. p. wheels run the blast furnace blowing engines, one 400 h. p. is used for the heavy plate mills, one 400 h. p. wheel is set aside for two bar and nail mills, while three 200 h. p. wheels are used for the mills and machinery. The paper from which this description is taken adds: "In possession of a large supply of ores of exceptional purity, of an unlimited water power, cheap fuel and good transportation facilities, these works combine many of the most essential elements of success." *

Wood refuse for furnace gas.

The Swedes have mastered the art of converting wood refuse into furnace gas for open hearths making steel. A description of the Domnarfvet iron works, near Falun on the Bergslag railway, states that the open hearth furnace "is charged with bar ends and Bessemer scraps which, owing to the low temperature in the Bessemer converters, cannot be worked in them. For this and many of the other furnaces sawdust and other refuse is used in gas producers. These are chambers with cylindrical stacks, 7 feet diameter, 12 feet high, contracted by a conical fire box to 4 feet diameter at the bottom, where there is an ordinary fire grate. The top is covered by a flat brick arch perforated by a tube, forming the feeding hopper, which is closed by a movable cone of the kind ordinarily used in blast furnaces. An upright pipe in the ash pit, terminating a little below the level of the grate, serves for the admission of the air. The gas produced passes downward by a rectangular channel in the brickwork of the stack to the condenser, a rectan ular iron box about 12 feet long, $2\frac{1}{2}$ feet broad and about 6 feet deep, divided internally by partitions reaching nearly to the roof and floor alternately into a series of cells through which the gas is made to travel in a zig-zag direction, and encounters at the top of each alternate division a series of jets of water which cool it and remove the steam and other condensable substances with which it may be mingled and deliver it in a dried state to the main gas flue, whence it flows into the regenerators in the usual way." † Plans of various forms of producers for using sawdust for fuel, for using short wood and using long wood in the manufacture of gas, are given in the Journal of the United States Charcoal Iron Workers Association. It is stated that some years ago an attempt was made at Brockville in this province to gasify cordwood for mixture with coal gas for the illumination of the town. The quantity of hydrogen gas generated was of course excessive, and the attempt therefore was abandoned. Sawdust has been compressed into slabs and bricks and mixed with tar for avoiding the risk of explosives which have attended the earlier efforts to gasify it in retorts. The grinding of it with anthracite or other coal waste and making the combination plastic by the addition of petroleum might be undertaken by means of some of the many recent machines in very successful operation in England for manufacturing briquettes of patent fuel. Or it is suggested that it might be incorporated in a similar process with some of the Ontario bituminous shales, whose value in the gas generator will come up for consideration when the use of abundant supplies of gaseous fuel in iron and steel works in the province shall be a necessity. A paper on the iron industry of Hungary states that in Ferdinandoberg there are five gas double puddling furnaces fired with wood and three welding furnaces in Burjorkova similarly worked, and so with the works of Kudsir, where there are two double gas puddling furnaces and two gas welding furnaces. The timber employed as fuel, mostly beechwood, is introduced into generators which have the form of a pit.

* Charcoal Iron Workers Journal, vol. I, p. 13.

† Ib., p. 15.

THE VALUE OF WATER-POWER.

A reference may not be out of place here to the influence of water-power in promoting the manufacturing prosperity of the neighboring Union, on the authority of Mr. J. B. Francis, president of the American Society of Civil Engineers: "At Paterson, N.J., where the Society for Establishing Useful Manufactures was formed in 1791, the Passaic river when at a minimum furnishes 1,100 h. p. The water-power of Lowell, Mass., was begun to be improved in 1822. The Merrimac river here furnishes 10,000 h.p. At Cohoes, N.Y., the Mohawk could supply 14,000 h.p., but only a part of the power is available owing to the way the works are arranged. At Manchester, N.H., the Merrimac furnishes 10,000 h.p. At Lawrence, Mass., the minimum power is 10,000 h.p.; at Holyoke, Mass,, 17,000 h.p.; at Lewiston, Maine, 11,000 h.p.; at Birmingham, Conn., 1,000 h.p.; at Passaic, N. J., 900 h.p.; at Turner's Falls on the Connecticut river, 10,000 h.p. I have named the above water-powers as being developed in a systematic manner from their inception. In the usual process of developing a large water power a company is formed who acquire a title to the property, embracing the land necessary for the site of a town to accommodate the population which is sure to gather around an improved water-power. The dam and canals or races are constructed, and mill sites with accompanying rights to the use of the water are granted, usually by perpetual leases subject to annual rates. This method of developing water-power is distinctly an American one, and the only instance where it has been attempted abroad that I know of, is at Bellegarde, in France." When there are a succession of falls within twenty miles of a railway centre or other eligible site, 70 per cent. of the effective horse-power furnished by turbines at any fall may be thus united by now highly improved electric apparatus for the transmission of power. The structural and mechanical appliances which an abundant supply of water-power enables the mechanical engineer to use in metallurgical processes, along with an abundant supply of fuel from sawmills, indicate great advantages to be derived from the location of iron manufactures at hydraulic sites in the lumbering district. When along with these the forest resources are sufficient to insure a large supply of charcoal fuel for many years, the creation of an industry which will be of great value to settlers affords an additional inducement. But when it is considered that abundant and cheap motive power, with reasonably cheap fuel, at some some central point in the mineral district of eastern Ontario for example, and where railway facilities can be had, might be expected to afford means for the development of the following manufactures of raw material, the inducement should be sufficient to promote enterprise in this direction:

Water-power as an element of manufacturing prosperity.

Iron manufactures at hydraulic sites.

1. Iron smelting.
2. Direct process for making blooms from ore.
3. Crushing and concentrating iron ores for local works and for exportation.
4. Manufacture of open hearth steel.
5. Roasting pyritous ores and barium, and manufacture of sulphuric acid.
6. Grinding and chemical manipulation of phosphate of lime.
7. Lead smelting.
8. Manufacture of retort charcoal and distillation of chemicals from wood.
9. Manufacture of acetate of lead and other acetates.
10. Reduction of copper and other ores from Sudbury and the lake Superior region.

EXPERT KNOWLEDGE A NECESSITY.

With no adequate industrial development of mineral resources beyond labor of mining and exporting raw material, to be purchased after paying tribute at two customs barriers, with the additional tribute to the foreign artisan for the manufactured product, the province will have at least this advantage in entering upon a new career of enterprise for the development of mineral resources, that metallurgical science has advanced more in the past

The value of expert knowledge to the iron industry.

fifteen years than in any previous period. In no department of human activity is thorough mastery of recondite processes more necessary, and in no other enterprise has the path of progress been strewn with so many failures. As a striking illustration of the precision required in testing new discoveries, it may suffice to point out that in 1855 the Geological Survey of Canada drew attention to the Chenot method of making iron sponge or spongy iron as a method of dephosphorising and desulphurising, and thus furnishing a pure product for compression and fusion in crucibles for the manufacture of steel. The process had the endorsement of the highest authorities in Great Britain and on the continent, and theoretically it is unassailable so far as the chemistry of the process is concerned. The practical difficulties of the process however have stood in the way of its successful application, and while it is even now omitted from no respectable authority in the list of metallurgical processes for the reduction of iron ore it is stated that in no instance is it in practical operation. The obvious necessity for protecting as well as instructing the enterprise of this province by establishing a School of Mines in which the chairs shall be given to Swedish scientists acquainted with the mineralogy and lithology of the Laurentian formation, and able to impart with authority the knowledge of metallurgical skill most suitable for dealing with the natural conditions and for developing the natural resources of this province, rests upon the fact of similarity of environment and the custom of successful iron masters to employ the best men. Lord Armstrong, himself an iron king, says: "Every iron master in the kingdom will acknowledge the necessity of either making himself an expert in the branches of knowledge concerned in the process of smelting, or of employing qualified specialists to supply his own deficiencies."

Swedish experts.

I.—THE HUSGAFVEL BLAST FURNACE.

In the evidence of Mr. James Lobb reference is made to the manufacture of Russian sheet iron from blooms of magnetic iron ore smelted in the Husgafvel furnace. An estimate of the cost of Husgafvel furnaces of 4½ tons daily capacity was placed in the hands of the Commission by Mr. Lobb, from which it appears that a plant consisting of three furnaces, engines, hoist, breaking machine, buildings, etc., could be erected for about $31,000, and that a furnace alone could be erected at a cost of about $3,200. The estimate further showed that charcoal blooms could be produced at $15 to $16 per ton and coke blooms at $17 per ton, at prices for ore, fuel, flux, labor, etc., in St. Petersburg or Olonetz, including a royalty for the patent.

Double shells and movable hearths.

The claim for the Husgafvel furnace is that it produces malleable iron and steel from ore by the direct process, and for this purpose it is constructed with double iron shells and movable hearths. A paper written by Husgafvel and published in the Jern-Kontorets Annaler in 1887, reproduced in volume VII of the Journal of the United States Charcoal Workers' Association, gives a lengthy account of his experiments in furnace construction and of the results finally obtained. "It is well known," Husgafvel writes, "that malleable iron and steel are produced chiefly from pig iron by being refined in various ways, and to avoid indirect and costly methods has long been and still is the desire of metallurgists in different countries. Most of the methods for producing iron directly from ores known up to the present time have failed, so that many of them exist only on paper, and none have practically gained well-known or important use. The failure of these methods has naturally caused a strong prejudice amongst metallurgists against all direct methods in general, and authorities have raised their voices against trials with them. If on the one hand these circumstances have increased the difficulties for inventors to have their ideas accepted or put in practice, they should on

Experiments with the direct method.

the other hand stimulate the inventor to test the value of each method impartially. The above-mentioned reasons, as well as a want of sufficient capital, caused the method herein described for the direct production of malleable iron from the ores (the development of which has consumed twelve years of work) to be unknown to the public until the present time, and even now it is not developed to such perfection that it cannot be improved in technical and economical respects. The results obtained from the furnace in Finland, and recently in the iron works of Count Stroganoff at Drobiansky, in the Ural, Russia, nevertheless show that the principles in the construction of the furnace are correct, and that there is no doubt or uncertainty in judging of and regulating the smelting operations. The principle which lies at the bottom of the process is the so-called 'Astman' or 'Hark' process, well-known to and used by our ancestors, but the manner in which my process is operated differs so much from the older ones that it may be considered as essentially different. . . . The first improvement was in 1875, when a movable hearth was constructed, which in the beginning was made of three-eighths inch plate iron and the interior lined with clay, quartz and lime. In consequence of frequent repairs to this lining the hearth was replaced with one of cast iron without any lining. Since a continuous operation of the furnace was obtained with the movable hearths there appeared to be a possibility of obtaining better results than before with furnaces of greater dimensions. . . . In order to make it possible to regulate the changes of temperature which were caused by non-homogeneous materials, or by other reasons, and at the same time to cool down the lower portion of the furnace, it occurred to me to try hollow furnace walls, and to allow the cold blast before it reaches the tuyeres to pass through these hollow walls, which must thereby be cooled down, while at the same time heating the blast. . The results obtained lead to the following conclusions: First, by the passage of the blast through the walls of the furnace they are kept so cool that there is no danger of their being burned or oxidised, even if made of iron plate without lining. Second, this method of heating the blast affords a means of regulating the operation of the furnace. To increase the temperature of the blast and, when desired, to alter it, it further occurred to me to provide the furnace with double walls of plate so arranged that the cold blast can be admitted between them at different levels. This arrangement for the admission of the blast between the walls of the furnace also enables alterations to be made in the furnace itself, and thus regulate the operation of the process. In the year 1884 this principle was applied, and a furnace with double walls of soft plate iron was erected at the Wartsila iron works. . . . The favorable results obtained with the Wartsila furnace in all respects, when compared to those of any of the preceding furnaces, is considered to be caused by the circulation of the blast between the walls of the furnace in connection with the forcing of the blast through several tuyeres into the hearth itself. The former prevents the too early 'sintring' of the ore and the charge from sticking to the walls of the furnace. The iron is not oxidised when the blast is forced into the hearth itself, which at each change of the hearth is filled with charcoal, and the several tuyeres with which they are provided tend to make the product more uniform. . . . Considering the process going on in the Husgafvel furnace, it has been suggested that the chief reason of the product being malleable iron or steel must be attributed to the fact that the ore charges are higher per unit of charcoal than in the case of a blast furnace. The ore is charged with the flux, lime or dolomite, so that the earthy matter as well as a part of the unreduced iron may combine with it and form as easily melted and quick slag as possible. The blast is conducted through the hollow walls of the furnace, the consequence of which is that the stack is kept comparatively cool, and at the same time a high temperature is produced in the hearth and lower part of the furnace. The blast is heated during its

The movable hearth device.

Hollow furnace walls utilised to heat the blast.

Regulating the temperature of the blast.

How the malleable iron is produced in the Husgafvel furnace.

passage through the walls, cooling down the stack and retarding the reduction of the ore by the charcoal, so that the reducing action is concentrated in the lower part of the furnace, not much above the tuyeres, in consequence of which the reduced iron has not time to take in sufficient carbon to form pig iron. Thus the carbonisation generally stops before a more or less hard steel is formed, which at the tuyeres is in a more or less doughy condition and sinks down through the thin fluid slag, beneath which it coagulates itself and forms a bloom. In passing the tuyeres during the 'sinking' the greater or less part of the combined carbon is oxidised according to the direction given to the blast in the hearth. One part of the carbon thus removed, it may be further oxidised by the action of the blast upon the surface of the bloom. It should here be observed that the iron in the bloom is partly compact and partly solid, like blooms which are produced by the refining of pig iron in a hearth, and not like iron sponge, as might be supposed. Besides, by the inclination of the tuyeres the carbonisation of the reduced iron can be regulated both by the ore charged, the quantity of air supplied and the height at which the blast is introduced through the iron mantle which surrounds the furnace. It is also obvious that the process can be conducted so that, instead of wrought iron or cast steel, pig iron can be produced. The reason of this is that in this furnace more ore can be charged on the charcoal than in a blast furnace, and the iron is not so completely reduced; which circumstances compensate in many cases for the loss of iron which takes place in the conversion of pig iron into malleable iron. . . . In the Husgafvel furnace peculiar appliances for lowering the temperature are used, and by their means the heat is kept away from those parts of the furnace where a high temperature is not only necessary but even detrimental; in other words, this superfluous heat is taken up by the blast and introduced into the hearth where it is needed. The above-mentioned lowering of the temperature causes no injurious effect on the proper working of the furnace, provided the inner shell is surrounded with a bad conductor of heat. Except for the heating of the blast, the regulating of the smelting process and the working of the furnace, the object of the introduction of the blast between the walls of the furnace is to cool them down so as to prevent the iron from sticking to them and forming a scaffold; it also checks the reduction of the ore by solid carbon."

Regulating the process.

J.—THE HENDERSON STEEL CONVERTER.

BY E. C. GARLICK, METALLURGIST, CLEVELAND.

The plant.

The Henderson experimental steel plant now running at Birmingham, Alabama, is essentially a basic open hearth furnace and consists of a gas producer and reducing and dephosphorising hearth lined with magnesia, brick and lime, with a reverbatory furnace attached, acid lined for the purpose of desiliconising pig iron high in silicon, which may also be used for melting pig for the dephosphorising chamber.

The gas producer.

Points of difference from other furnaces.

The producer and the two hearths are placed in a direct line and the gas and flame from the producer are taken into each respectively through a neck and short flue, after which they pass into a heating oven containing iron pipes and thence under the boiler of the engine and out through the smoke stack. This furnace differs from the open hearth furnaces in general use, first in the form of the gas producer and the use of a forced blast in contradistinction to a draft. The producer is round and is made with a closed bottom without grate bars, and the blast is conducted into it near the bottom through tuyeres placed at equal distances apart. Fuel is charged through an aperture at the top, which is closed automatically by a simple mechanical contri-

vance. The ash-pit of the fuel is fluxed with fluorspar and lime, melted and drawn off through a tapping hole. Secondly, the first furnace of the dephosphorsing hearth is lined with basic material.

On my arrival at Birmingham on the 18th of December, 1888, I found that by an accident to the blowing cylinder the plant was incapacitated for use. First test. Repairs and the time consumed in heating the furnace to the required temperature to enable me to conduct my experiment consumed ten days. On December 28th the first heat was made with the furnace in a satisfactory condition, with the following result:

Furnace charged at 9 a.m.; heat drawn at 1.30 p.m.; time required for conversion, 4 hrs. 30 min.

Charge: Pig iron 3,225 lb.; wrought scrap 1,140 lb.; 80 per cent. ferro-manganese 40 lb.; fossil ore (Alabama) 80 lb.; limestone 240 lb. and fluorspar 100 lb.

Product: Weight of ingots 3,962 lb. and scrap 255, making a total of 4,217 lb.

Analysis: Weight of iron and scrap charged, 4,365 lb., to which add iron contained in 80 lb. ore (50 per cent.) 40 lb., making a total of 4,405 lb. Deduct product of heat 4,217 lb., and the loss is 188 lb., or about four per cent.

Tests made with the sample ingots were very satisfactory. When drawn out in a blacksmith's forge into forms one-quarter of an inch thick the samples An excellent quality of soft steel. turned cold either with the grain or across it, without a fracture. The pig iron samples together with the test bars taken during the heat were forwarded to Cleveland for analysis, with one of the ingots of steel to be rolled into plate and other forms for a practical test. I regret that these have not been received. An analysis for comparison with that of other known brands and tests of the manufactured product mechanically would demonstrate conclusively its value. It is safe to say however that the resulting product of the experiment is an excellent quality of soft steel.

The second experiment was made with Canadian magnetic ore. Furnace Second test, with Canadian magnetic ore charged at 3 p.m.; heat drawn at 8 p.m.; time required for conversion 5 hrs.

Charge: Pig iron 3,000 lb.; Canadian magnetic ore 500 lb.; red mountain (Alabama) fossil ore 50 lb.; fluorspar 100 lb.; and 80 per cent. of ferro-manganese 40 lb.; a total of 3,690 lb.

Product: Weight of ingots 2,953 lb.; scrap 205 lb.; making a total of 3,158 lb.

Analysis: Weight of pig iron charged, 3,053 lb.; iron in Canadian ore, (60 per cent.) 300 lb.; Alabama iron ore (50 per cent.) 25 lb., making a total weight of iron charged 3,325 lb. From this deduct the product of the heat 3,158 lb., and the loss is 167 lb., or 5 per cent. As the loss in the best open hearth practice to 6 per cent., it follows that $32\frac{1}{2}$ lb. of the quantity contained in the ore was reduced to steel.

Demonstration: Quantity of iron charged 3,325 lb., 6 per cent. on 3,325 lb. is 199.5 lb., while loss as above is 167 lb., leaving a difference in favour of the Henderson process of 32.5 lb.

An analysis of the ingots gave carbon $0.10\frac{2}{3}$, phosphorus 0.316, sulphur 0.286, manganese 0.316. The Canadian ore contained 2.64 per cent. of sulphur, which amounts to 13.20 lb., to which should be added that contained Elimination of sulphur in the magnetic ore. in the pig iron, say 15 lb., making an aggregate of 28.20 lb. to be eliminated. During the greater part of the heat sulphurous fumes escaped in large quantities at the charging doors, covering them a dirty brown color, and through the smoke stack, changing the color of the escaping gas from white to a brown color. Upon attempting to draw a test bar in the blacksmith's fire it showed the characteristic feature of iron high in sulphur and cracked to such an extent that it could not be welded up, and consequently could not be drawn out as the test bars usually are.

To test the power of the furnace farther in the way of eliminating sul- Third experiment. phur, the following experiment was made:

Furnace charged with 1,000 lb. of ingots from former heat, 2,600 lb. pig iron, 1,000 lb. wrought scrap, 360 lb. lime, 50 lb. fluorspar, 225 lb. 20 per cent spiegel and 60 lb. 80 per cent. ferro-manganese. This heat was run in the usual manner and gave a product that stood all the usual tests, and appeared to be equal to that

made upon the average during the ordinary run of the furnace. A test bar was drawn out in the blacksmith's fire to a quarter of an inch in thickness by about one and one-half inches in width and ten inches in length. It was turned over cold and the end driven down solid without showing a crack. An analysis of the piece gave carbon .111, silicon .041, sulphur .117, phosphorus .034 and manganese .920.

The furnace not designed to work raw ore.

Having conducted the above experiments with so large a quantity of sulphurous ore in the furnace to a successful termination, it may be remarked that the furnace under consideration was not designed to work raw ore, either for the purpose of reducing it to metallic iron or of eliminating impurities from it, but was designed for and its legitimate use is for the purpose of converting pig iron into steel. One of the reagents used in the process of conversion is a small quantity of oxide of iron, which the patentee directs shall be as free from sulphur and silica as possible. Obviously the purer the ore is that is used for this purpose the better. Since making this experiment I have become convinced that pig iron made from well roasted ore containing sulphur (such as was employed in this experiment) when properly treated in a basic hearth lined with basic reagents will produce steel of an excellent quality. If the iron should contain too much sulphur, as it undoubtedly would to be successfully used in the acid process, the result would I believe be satisfactory when the basic method is employed.

Cost of production.

The estimated cost of making the conversion if two ten-ton furnaces are employed is $7 per ton of steel ingots. In this estimate coal is valued at $2 per ton, ferro-manganese at $65, magnesia at $26 and spiegel at $26.50. Other materials and conditions must compare favorably with those prevailing where iron is successfully manufactured in the United States.

Comparative analyses of steels.

I append herewith analyses of steel made in the United States by different manufactories, and also analyses of ingots made by the Henderson Steel and Mfg. Co. of Birmingham, Alabama.

Nashua plate		Scotia blooms		Otis Iron Co. plate	
Carbon	0.070	Carbon	0.060	Carbon	0.130
Phosphorus	0.106	Phosphorus	0.069	Phosphorus	0.066
Sulphur	0.067	Sulphur	0.027	Sulphur	0.078
Manganese	0.470	Manganese	0.320	Manganese	0.510

Park Bros.		Henderson Steel & Mfg. Co.			
		No. 1.		No. 2.	No. 3.
Carbon	0.110	Carbon	0.750	0.400	0.120
Phosphorus	0.033	Phosphorus	0.050	0.070	0.080
Sulphur	0.022	Manganese	trace	0.770	0.550
Manganese	0.330				

All of the steel above referred to except that of the Henderson Steel Co. was made by the acid process from the best pig iron and wrought blooms (or their equivalent in other forms of wrought iron) in the market, and it will be observed that the analysis of the blooms or ingots made by the Henderson Steel Co. from the phosphoric white pig iron made of the fossil ore of Alabama compares very favorably with those made from the low phosphorus ores of the north.

The Henderson patents.

The Henderson patents number 52 and date back to the year 1870, at which time patents were issued to him in England covering the fundamental features of the basic process for the manufacture of silica and magnesia brick and other refractory materials for furnace linings. Since that time he

has received patents from the government of the United States embodying claims covering many details of the invention and processes for the manufacture of refractories.

The characteristic features of the basic process for the conversion of impure pig iron, scrap or other wrought iron blooms into soft steel or homogeneous and pure iron for commercial purposes consist in its greater capacity for recovering impurities by means of the basic reagents employed in the treatment of the iron in a basic lined furnace, and especially the removal of the greater part of the objectionable silicon as well as the phosphorus, leaving the resulting product more ductile and flexible than that made from better stock by the acid process. The manufacturer therefore derives a great advantage from its use by being enabled to use cheaper material in all cases to produce a required product, and in other instances to convert iron high in phosphorus, sulphur and other impurities into a commercial article of good quality which cannot now be done by any other method in practical use.

The basic process.

K.—EARLY USE OF THE MAGNETIC SEPARATOR.

BY DR. ROBERT BELL, ONE OF THE COMMISSIONERS.

The sands along the north shore of the gulf of St. Lawrence are in many localities largely mixed with grains of magnetic iron, forming beds called black sands, interstratifying not only the ordinary sands of the present sea beach but also those of low terraces or raised beaches above the present high water mark. The black sands are particularly abundant about the mouth of the Moisie river, and about the year 1871 operations were begun for separating and smelting these magnetic sands. Mr. Markland Molson of Montreal was the leading spirit in this enterprise. The magnetic sand was concentrated by a separator invented by a Mr. Larue of Quebec.* It consisted of a rotator bearing temporary magnets covered with cloth which carried the magnetic particles out of the natural mixture as it was fed to the machine, and deposited them on the opposite side of the wheel, from which they were conveyed to the smelting furnace. This fine ore was reduced by charcoal made from white birch, which grows abundantly all along the valley of the Moisie, and from it an excellent quality of malleable iron was made. This iron was admitted to be well suited for the manufacture of the finest steel for cutlery, and Mr. Molson endeavored to find a market for it in England, but failed to do so as the consumers there were unwiling to transfer their orders from the Norwegian and Swedish producers, from whom they had been so long accustomed to buy. After a few years the enterprise was abandoned. The isolated position of the works was another serious drawback. All materials and almost everything required for the support of the colony had to be brought from a distance. The men and their families were all brought to the ground for this service, and hence the masters became dependent upon the men, and the latter were able to dictate the terms on which they would remain.

Magnetic iron sand on the gulf of St. Lawrence.

Concentrated by a magnetic separator.

A fine quality of charcoal iron produced.

L.—TECHNICAL INSTRUCTION.

On the 25th of August, 1881, the government of Great Britain appointed a Commission composed of Bernard Samuelson, M.P., F.R.S,, Prof. Henry Enfield Roscoe, LL.D., Philip Magnus, B.A., John Slagg, M.P., Swire Smith and William Woodall, M.P., to enquire into the instruction of the industrial classes of certain foreign countries in technical and other subjects, and on the

*Dr. Sterry Hunt's suggestion of a magnetic separator for the treatment of ores was published in 1869. See page 346.

4th of April, 1884, their report was presented. The following excerpts, bearing upon the technical education of miners and metallurgists, are taken from the volumes of the Commissioners' report:

NORMAL SCHOOL OF SCIENCE AND ROYAL SCHOOL OF MINES.

The Normal School of Science at South Kensington.

The Commissioners visited the Normal School at South Kensington, and were received by the registrar, General Martin, who accompanied them over the building. This school, which was reorganised in 1881, gives systematic instruction in mathematics and mechanics, physics, chemistry, biology and botany, geology and mineralogy, agriculture, metallurgy and assaying, elements of astronomical physics, practical geometry and mechanical and freehand drawing. Mining is taught at the museum of practical geology in Jerymn street, but forms part of the normal school. The normal school is primarily intended for the training of science teachers and the instruction of students of the industrial classes, selected by competition in the annual examinations of the science and art department; but other students are admitted on payment of prescribed fees. The students may be (1) occasional students, and (2) regular students who are preparing for the associateship of the school, and pass through a prescribed course extending over three to three and a half years. The instruction for the first two years for all the associate students is the same, and includes mechanics and mathematics, physics, chemistry, elementary geology, astronomy, mineralogy and drawing. The student then elects to take up one of the following divisions, to which the remainder of his course is directed, viz., for the title of Associate of the Normal School of Science, I, Mechanics, II, Physics, III, Chemistry, IV, Biology, V, Geology, or VI, Agriculture; and for title of Associate of the Royal School of Mines either VII, Metallurgy, or VIII, Mining.

Exhibitioners

There are twelve exhibitions each of the value of £50 per annum tenable at this school, and continuing during the course of time (three to three and a half years) necessary for the preparation for the associateship examination. The exhibitioners have also free admission to the lectures and laboratories. Three or four are vacant each year, and are competed for at the May examinations of the science and art department. Six free studentships are also similarly annually competed for. These correspond to the exhibitions, except in so far that they carry no money grant.

Free instruction and maintenance allowance.

Free instruction is likewise given to local exhibitioners, who hold scholarships of the value of £50 per annum, half of which sum is subscribed by the locality and half by the department. There are also royal scholarships, four of £15 for first year students and two of £25 for second year students. About fifty science teachers or students intending to become teachers also receive free instruction, and in addition are paid the railway fare to London and receive a maintenance allowance of 21s. a week whilst under instruction.

Summer courses.

During the summer vacation short courses of lectures, extending over three weeks, are given to science teachers, about 200 in number, who are aided by the department in the payment of the expenses of the journey to and residence in London during the progress of the course. Courses of popular evening lectures for workingmen are also given by the professors.

Laboratories.

The Commissioners first visited the metallurgical laboratory which had recently been fitted up in the basement of the building. The chemical laboratories under the charge of Prof. Frankland were inspected, and also the physical laboratory of Prof. Guthrie and the physiological laboratory under Prof. Huxley. The Commissioners had conversations with the professors on the system of science teaching adopted in the school.

Methods of practical and theoretical instruction.

Prof. Huxley, the dean of the school, explained the methods of practical and theoretical instruction given under his guidance in the department of biology, which includes an important museum and a large collection of preparations and diagrams arranged for the special purposes of study. Pure and applied geology under Prof. Judd forms an important feature of the science instruc-

tion, and the students are brought into close contact with the subject by the microscopic preparation and examination of rock sections and other practical geological work. Prof. Guthrie explained the way in which he had introduced laboratory work in physics, every student having to construct certain simple physical apparatus. Prof. Chandler Roberts stated that in his department (that of metallurgy) there were thirty working places. Since coming to South Kensington he had a large addition of students, and there were now forty under instruction, and it needed much ingenuity to arrange the places for them. In the chemical department the numbers have slightly fallen off. On the occasion of their visit to the museum in Jermyn street the Commissioners were received by Prof. Warington Smyth, F.R.S., and Mr. Rudler, the curator. Since the transfer of the school of mines to South Kensington in 1881 the practical science teaching, except in the case of mining students who take part of their instruction here, has virtually ceased. Evening science lectures for workingmen take place during the session; the charge for admission to each course of lectures is sixpence. There is a good library, a small chemical laboratory, a lecture theatre and the necessary class-rooms. The geological collection, first known as the museum of economic geology, was transferred to Jermyn street from Craig's Court in 1851. The museum was designed to illustrate mainly the geology of Great Britain and Ireland, and to show the applications of geological science. It contains specimens of minerals, including the ores of the useful metals and models representing metallurgical processes. The various arts connected with the mineral resources of the country are illustrated by specimens showing varieties or peculiarities of manufacture. An excellent historical collection of English pottery and porcelain has been added, and there is a very complete series of English building stones. The collection of models of mines, mining tools and mining machinery is very extensive. All the varieties of safety lamps are shown. The mining record office, which was formerly situated at Jermyn street, was transferred to the home office in 1882. The offices of the Geological Survey of Great Britain are also at the museum.*

Museum of Practical Geology and Royal School of Mines.

The geological collection and museum of models.

WIGAN MINING AND MECHANICAL SCHOOL.

Alfred Hewlett, managing director of the mining and mechanical school at Wigan, furnished the following statement to the Commissioners in 1883: "1. A mining and mechanical school is established in Wigan, and affords excellent technical education at a very small cost to each student. Wigan is the centre of a large manufacturing and mining district. The school is very accessible to that district. Mining in all its branches is taught; mechanics, theoretical and applied metallurgy, chemistry, steam brick-making, etc. The classes are well attended. The instruction afforded is found most useful to both workmen and foremen, and especially is it so to youths who aspire to become foremen, managers or proprietors. This school has been at work over twenty years. It is supported principally by the coal owners and iron masters in the immediate neighborhood of Wigan. 2. In my judgment the instruction afforded is suited to the requirements of the district. I scarcely think it could be made more useful. The maintenance of such an institution falls heavily upon a few persons, but I see no help for that unless the whole expense were undertaken by the government, which I should not desire."† Mr. Peace, secretary and solicitor to the Mining Association of Great Britain, stated in his evidence before the Commission that the school was established in 1858. It has given the mine owners and other employers of labor a class of people who are specially trained scientifically for the carrying on of the industries of the neighborhood. It is attended among others by persons who aspire to be foremen, "knowing that the fact of passing this

The Wigan mining and mechanical school.

* Report on Technical Instruction, Vol. I, pp. 397-9.

† Ib., vol. III, p. 654.

examination gives them a claim for promotion at the first opportunity," and the principal officials at nearly all the local works have been students of the school. The instruction comprises "the whole range of smelting, puddling, rolling, the Bessemer process, the Siemens-Martin process, and all machinery used in iron and steel manufacture."*

TECHNICAL HIGH SCHOOLS IN EUROPE.

Training of technical directors for industrial establishments.

Technical high schools now exist in nearly every continental state, and are the recognised channel for the instruction of those who are intended to become the technical chemists of industrial establishments. Many of the technical chemists have however been and are being trained in the German universities. Your Commissioners believe that the success which has attended the foundation of extensive manufacturing establishments, engineering shops and other works on the continent could not have been achieved to its full extent in the face of many retarding influences had it not been for the system of high technical instruction in these schools, for the facilities for carrying on original scientific investigation and for the general appreciation of the value of that instruction and of original research which is felt in those countries.

The schools created and maintained as state institutions.

With the exception of the Ecole Centrale of Paris all these schools have been created and are maintained almost entirely at the expense of the several states, the fees of the students being so low as to constitute only a very small proportion of the total income. The buildings are palatial, the laboratories and museums are costly and expensive and the staff of professors, who are well paid according to the continental standard, is so numerous as to admit of the utmost subdivisions of the subjects taught. In Germany, as we have stated in a previous part of our report, the attendance at some of the

A present excess in the supply of trained men.

polytechnic schools has recently fallen off, chiefly because the supply of technically trained persons is in excess of the present demand; certainly not because it is held that the training of the school can be dispensed with. The numerous young Germans and Swiss who are glad to find employment in our own manufactories have almost without exception been educated in one or other of the continental polytechnic schools. Your Commissioners cannot repeat too often that they have been impressed with the general intelligence and technical knowledge of the masters and managers of industrial estab-

High qualifications of industrial directors and managers in Europe.

lishments on the continent. They have found that these persons as a rule possess a sound knowledge of the sciences upon which their industry depends. They are familiar with every new scientific discovery of importance, and appreciate its applicability to their special industry. They adopt not only the inventions and improvements made in their own country, but also those of the world at large, thanks to their knowledge of foreign languages and of the

The schools for foremen.

conditions of manufacture prevalent elsewhere. The creation abroad of technical schools for boys intending to become foremen is of much more recent date than that of the polytechnic schools. To this statement the foundation during the first empire of the three French Ecoles des Arts et Métiers at Chalons, Aix and Angers is only an apparent exception, because they simply vegetated until their reorganisation within the last twenty-five or thirty years. Mining schools were however established in Prussia in the last century and in France about 1817. Among the examples of schools for foremen are those of Winterthur in Switzerland, Chemnitz in Saxony, and Komotau in the Austrian dominions, principally for engineers, and the Ecole des Mines at St. Etienne, the latter more especially for mining and metallurgy. The theoretical instruction in these schools is similar in character but inferior in degree to that of the great polytechnic schools. On the other hand considerable attention is devoted in these schools to practical instruction in laboratories

French and German schools for miners.

and workshops, which is not the case in the polytechnic schools. . . . The French and German schools for miners and the one which has been quite

* **Report on Technical Instruction, vol. III, pp. 161-66.**

recently founded in Westphalia for workers in iron and steel differ from the preceding schools for foremen inasmuch as they are reserved for the theoretical instruction of men who, having already worked practically at their trades, have distinguished themselves by superior intelligence and good conduct. Most of the German schools of this kind are founded or maintained by the manufacturers, and will, we feel confident, repay the trades which have had the foresight and public spirit to create them, by training young men to become foremen and leading hands, willing and able to carry out with intelligence the instructions of their superior officers.*

MINING SCHOOLS IN GERMANY.

In Prussia there are eleven schools for miners, containing altogether between four and five hundred students. Several of them have a group of preparatory schools in the district of which they are the centres affiliated to them. Thus the Bergschule of Bochum has ten preparatory schools, one with about 30 students in the town itself and nine others in the neighboring towns and pit villages with about 220 students, all of them pitmen or employed about the pits in some capacity. The instruction in these preparatory schools is given on the evenings of four working days, except drawing, which is taught on Sunday mornings. The course occupies two years; the subjects are the German language, arithmetic, drawing, elementary physics, and in the last half year explanations of the rationale of mine regulations. At these preparatory schools the miners may acquire sufficient elementary knowledge to be able to profit by the instruction in the mining school proper. The regulations of nearly all the German mining schools require that the students shall have been actually employed as workmen in mines before they can enter the school. The Saarbrück demands the minimum in this respect, namely, a full year's work as a pitman. The requirements are greatest at Bochum. The rule there is that candidates must have worked four complete years in the pit; they must produce certificates that they are industrious and skilful, and that their conduct is reputable. The minimum age of admission varies in different schools from 17 to 21. There is no maximum age. In practice the students in the schools are generally from 20 to 25 years of age. The candidates have to satisfy the examiners that they can read fluently, write legibly and correctly and are conversant with the four rules of arithmetic. Some of the schools also require some elementary mathematics and physics and more or less of drawing, the minimum being ability to make an outline drawing of the usual mining tools. The schools are generally held in government or municipal buildings, and the cost of instruction is defrayed out of a general fund subscribed by the mine owners. That of the school at Bochum is about £1,500 per annum, and of its preparatory schools about £600.

Groups of preparatory schools.

Course of the preparatory schools.

Students in mining schools must have been actually engaged as miners.

THE BOCHUM SCHOOL.

The Bochum school has a lower and an upper division; the former is a half-time school, the students continuing to work in the mines half the day. The instruction in this division occupies two years. It includes mathematics, mining, mechanics, drawing and natural science (physics and chemistry). The upper division occupies one year and the students do not work in the mines. It has two departments, one for mine surveying, the other for mining proper. The subjects taught in the former are mathematics, surveying, geology, mine accounts, mining law and the German language. Those taught in the latter department are mathematics, mechanics, geology, machine drawing, surveying and mining. It may be mentioned that in connection with the laboratory of this school a separate building has recently been erected for carrying on researches by a government commission on explosive gases and the conditions of their presence and explosion in mines. The Bochum school was not

Instruction in the upper division.

* Report on Technical Instruction, vol. I, pp. 508-10.

in operation when we visited it on account of the Whitsuntide holidays, but some notion may be formed of the scope of the instruction from that given in another mining school, that of Zwickau in Saxony, in which German includes essays on mining operations; mathematics includes quadratic equations and logarithms, geometry, proportions and elementary solid geometry; physics and mechanics include the properties of liquids and gases, with special practical applications, electricity and magnetism, and practical exercises in the theory of falling bodies, the mechanical powers, etc.; mineralogy and chemistry include crystallography, the minerals found in the coal measures and the principal ores of the metals; mining includes faults, sinking and boring, all branches of the working, drainage and ventilation of mines and the preparation of minerals at bank, etc.; and the instruction in machine construction, drawing, etc., is of a similar practical kind. About one-fifth of the students of the Bochum mining school ultimately rise to the position of mining engineers or mine managers, and a few to that of managing directors of mines.

THE RHENISCH-WESTFALISCHE HUTTENSCHULE, BOCHUM.

Metallurgical school at Bochum.

The necessity which was felt by the iron and steel manufacturers of Rhineland and Westphalia that their foremen and leading hands should possess some theoretical knowledge in addition to their practical workshop experience, and the satisfactory results of the establishment of mining schools in that district and elsewhere, have led to the creation at Bochum of a metallurgical school on the lines of the mining school of that town. With the exception of the mining schools this is the only continental school having a complete course of instruction to which only workmen who have already had regular workshop training are admitted, the candidates being required, as in the case of the mining school, to have worked at least four years in iron or mechanical engineering works before they are admitted. Certificates of competence and good conduct and satisfactory proof of elementary knowledge, including drawing, are also demanded as for the mining school. Indeed the regulations generally resemble those of that school, with the exception that the whole time is occupied with the work of the school, employment in the works being for the time given up. It is a municipal school, held in buildings formerly occupied by the Real, or as it was called, a Gewerbeschule. The government has undertaken to continue the subvention of £700 per annum which it paid to the former school; the town and the manufacturers contribute the rest, the latter body undertaking the maintenance of all or nearly all of the students. The course occupies three half years, the first being preparatory and general, the following two special in two divisions—one for metallurgy and the other for machine construction. The teaching staff consists at present of a director who is a chief engineer of iron works, together with a teacher of machine construction and drawing, one for mathematics and mechanics, one for physics and chemistry, and an assistant master for the German language and accounts. No class is to contain more than 40 students; should this number be exceeded parallel classes under proper teachers will be formed. Representatives of the contributing iron trades take part with those of the government and the town in the management of the school. The time table is as follows:

Qualification of students.

Government and municipal subventions.

The teaching staff.

In the preparatory class:

Drawing	6 hours weekly.
Arithmethic and mathematics	8 "
Physics	5 "
Experimental chemistry	6 "
The general principles of the metallurgy of iron and steel	7 "
German and business accounts	4 "

In the metallurgical division :

Drawing	6	hours.
Mathematics	4	"
Physics	4	"
Chemistry and laboratory work	10	"
Special metallurgy of iron and steel	12	"
German, etc	2	"

In the division for machine construction :

Mathematics	6	hours.
Mechanics	6	"
Machine construction and drawing	18	"
Physics	4	"
German, etc	2	"

Practical character of the instruction.

The teaching is as practical as that of the mining school. Without entering too much into detail we may state that in the metallurgical division no subject connected with the construction and management of blast furnaces and their appurtenances, with the practice of moulding and iron-founding, the puddling, refining and finishing of iron, the production and working of steel, the analysis of the raw materials, or the testing of the finished products is omitted; and that the course for machine construction includes all but no more than the mathematics which every mechanical engineer should know; and further instruction in theoretical and applied mechanics, in the properties of the materials ordinarily used in machinery, in the construction and necessary qualities of the elements of machines, as screws, rivets, axles, toothed gearing, cylinders, pistons, valves, etc., and in the construction of various complete machines, including lifting tackle of every kind, boilers, steam engines, water and gas motors, and in the economy of the workshop. Visits are paid to the surrounding works—36 important iron works, engine factories and other works having been visited by the students during the fifteen months preceding the last, which was also the first report. The age of the students, of whom there are 56, varied on entry from 18 to 34 years. They comprise 4 moulders, 1 puddler, 1 steel worker, 3 rollers, 1 erector, 3 smiths, 35 fitters, 3 turners, 1 boiler maker and 4 pattern makers. The cost of instruction is 10s. per term, or £1 10s. for the entire course. The laboratories and libraries are fairly complete and are daily receiving accessions. We have thought it desirable to enter into rather more particulars in regard to this school than in reference to some others, as it is the first example of its kind, and one the working of which should be carefully watched by our own metallurgists and engineers.*

MINING SCHOOLS IN FRANCE.

The Ecole des Mines.

The École des Mines, or as it was called till quite lately the École des Mineurs, is located in the coal basin of the Loire. The change of name is significant, for it indicates that the students leaving the school occupy a higher industrial rank than that which appears to have been contemplated at the outset. The school is proud of having educated several distinguished engineers and men of science, M. Boussingault being one of the latter. It is a government school under the direction of the minister of public works, and it furnishes in the first place the government sub-inspectors of mines, who however do not rise to the rank of chief inspectors, and second, sub-managers of mines and metallurgical establishments, some of these latter ultimately becoming managers of such undertakings. The age of students on entrance is from 16 to 25 years. Admission to the school is by competition. There is a preliminary qualifying examination in each department of France, and a subsequent competitive entrance examination of qualified candidates at the school itself. The examination includes the French language, arithmetic and logarithms, algebra, including the binomial theorem and the

Admission of students and course of study.

* Report on Technical Instruction, vol. I, pp. 115-118.

theory of logarithms, trigonometry, analytical, plane, solid and descriptive geometry, physics, optics and chemistry, more especially of the metalloids and metals, besides any other subjects which the candidate may select. It will be evident from the subjects of examination that the school is not intended for working miners. The instruction is gratuitous. It is given by three professors, and covers a course of three years, the school year beginning in October and ending in August. The first year's course comprises mathematics to differential calculus, theoretical mechanics and kinematics, physics, chemistry, mineralogy, geometry and surveying. The second and third years' courses are on applied mechanics, mining, metallurgy, geology, building and machine construction, railways, mining legislation and accounts. The number of students varies from 80 to 90. The budget of the school is £2,000.

Schools for overmen and deputies of mines.

The schools of the lowest grade are those for overmen and deputies of mines, of which there are two in France, one at Alais in the south, and one quite recently established at Douai, in the northern coal basin; and a large number in Germany, more especially in Prussia; the earliest of the German schools dating back to the last century, and an interesting example being the one established in 1793 at Steben by Alexander von Humboldt, then twenty-four years of age and mining engineer of the Franconian principalities. It will be convenient to include under the same head the metallurgical school established in 1882 for foremen and leading hands of iron and steel works and for foremen engineers at Bochum in Westphalia.

ECOLE DES MAITRES MINEURS.

Instruction at the Ecole des Maitres Mineurs.

The school at Douai (École des Maîtres Mineurs) which is a government institution, contains 35 pupils (20 in 1883). The instruction is gratuitous, the cost of each student's board is £20 per annum, and nearly all the students are maintained by "bourses" or scholarships, of which four are given by the town, four each by the départements du Nord and of the Pas de Calais, and the remainder by the colliery owners of the district. All of them are working miners, generally selected by the coal proprietors. The instruction, which is eminently practical, alternates from three months to three months, with work in the mines, and extends over two years. At the time of our visit it had not been established long enough for any judgment to be formed of its results. The budget of the school is £946, of which the payments of the teaching staff amount to £532.*

ÉCOLE CENTRALE DES ARTS ET MANUFACTURES OF PARIS.

A private and self-supporting establishment.

This important and well-known institution is designed to prepare students for the professions of civil and mechanical engineering, metallurgy and manufacturing chemistry. It was founded in the year 1826, chiefly through the interest of M. Dumas (whose recent death science has to deplore) and is essentially a private and self-supporting establishment, not receiving any grant from government, and depending entirely on the fees of the pupils, thus standing in striking contrast to other similar institutions on the continent. It has however lately been attached to the ministry of agriculture and commerce. The annual receipts amount to £20,640 and the disbursements to about £17,836, the difference being paid over to the new building fund. The school is at present located in an old building in the Rue des Coutures St. Gervais, totally inadequate to its needs, but it is shortly to be transferred to splendid premises about to be built near the Conservatoire des Arts et Metiers, chiefly at the government expense, though partly also at that of the school. There is a very strict entrance examination and great competition for the vacant places; of the 540 candidates who applied in the year 1881 only 220 were admitted. None of the students are boarded in the establishment. The regular course extends over three years and diplomas are given to the students at the end of the course after passing a

* Report on Technical Instruction, vol. I p. 114.

very severe examination and working out a thesis. A strict system of continuous examination and marking is carried out, the work which each student does being entered carefully by each examiner and the results of the whole three years' work are added up, the special grade of the diploma being given according to the result of this system of marking. The first year's course consists of instruction in general science, without much applied science, and is similar to that given in the École Polytechnique, whilst in the second and third years the teaching is especially directed to applied science, and is similar to that given in the École des Mines. The latter instruction has reference to the practical applications of each subject. The student who fails to gain his diploma at the end of the third year may pass the examination without re-entering the school at any period within six years after leaving the institution. The peculiarity of the education of this school is that the instruction is much the same for all students, and that there is scarcely any specialisation of the studies in accordance with the proposed career of the student. The difference is mainly shown, as hereafter explained, in the thesis or "projet" which the student prepares during the last year. Each of the 600 students pays £32 per year, and the governing body of the school manages the whole of its financial and other concerns. There are 30 professors attached to the institution, the chiefs of departments receiving £300 per annum, the others £4 for each hour of lecture. In addition there are two directors of studies and 30 tutors and assistant lecturers. The students on leaving the school and after having gone through its very severe discipline are glad to get situations of £72 to £80 per year. The director, M. Solignac, (whose salary is £400 per annum), furnished the Commissioners with a list of the present positions of all the pupils since the beginning of the school. A large number of manufacturers send their sons to the École Centrale. One of the most interesting features in the system of education in the École Centrale is the system of theses, which are written by the students at the end of their third year. The courses of instruction on which the theses are founded are divided into mechanics, metallurgy, technical chemistry and engineering. Each student takes up one or the other of these subjects for his thesis, as he deems fit, although the three years' course of instruction is not confined to any of these branches but comprises the subjects of all. The Commissioners inspected several of the theses of the outgoing students of former years in each of the above departments and were much struck with the detailed character of the work, and especially with the completeness of the drawings. The students are allowed to work at home, but have to produce the calculations, descriptions and drawings within one month from the time at which the subject is given out, and the whole work is carefully examined by a council of professors, the student being examined on the details of his thesis. One of the metallurgical theses which was examined was a plan and estimate for a blast furnace plant. This included the quantity and composition of the raw material to be treated, the chemical composition of the charges, the explanation of the changes which take place in the furnace, the cost per ton of the pig iron produced, the price of the raw material being given; then the construction of the plant, the hydraulic lifts and blowing engines, the reservoirs, the engine houses, the hot blast regenerating stoves, including a discussion of the amount of heat generated in the furnace and regenerated in the Whitwell stoves.*

Course of instruction.

Professors and students.

A system of theses.

THE ECOLE POLYTECHNIQUE OF PARIS.

This is a government school with military discipline, designed primarily for the education of persons to be employed in the service of the state, and differing in this respect from the polytechnic schools of Germany and Switzerland. . . The École des Mines, Paris, which is a branch of the École Polytech-

The Ecole des Mines.

* Report on Technical Instruction, vol. I, pp. 177–179.

nique, admits students who are not necessarily destined for government service. The Commissioners visited this school under the guidance of Prof. Daubrée, the director of the institution, and Prof. Friedel, who has charge of the celebrated collection of minerals in this school. Two classes of students are admitted, who may be termed respectively regular and occasional students. Practical instruction is given in all the departments relating to mining, but especially in metallurgical operations and chemical analysis. The laboratories, though not very extensive, are well arranged and well appointed. The government students are admitted from the polytechnic school. External pupils have to pass a competitive examination and the successful candidates are trained to become directors of mines and metallurgical works. The course of study lasts three years, the instruction is gratuitous, and the curriculum is thoroughly adapted to the object in view. The instruction is of the highest kind, and in some respects it resembles that of the Royal School of Mines, South Kensington.*

THE POLYTECHNIC SCHOOL OF DELFT.

Foundation of the school.

This school, founded in accordance with the law of 1863, was opened in 1864, at which time it contained ninety-one pupils. It replaced the former academy, which at that date contained 259 students, many of whom were transferred to Leyden to the school established by the government for the study of the language, geography and ethnology of the Dutch colonies in the East Indies. . . Special diplomas are given to engineers and architects on the results of the annual examinations. Some few mining engineers are in receipt of scholarships to enable them to visit German and other mines, and after having obtained their diplomas they are appointed under government to the various mining establishments in the Dutch Indies. . . There are about thirty students in the department of mechanical engineering, but accommodation has been provided for a much larger number. All the rooms seemed large for the number of students present. There is a collection of minerals, etc., for the mining engineers, and a small metallurgical laboratory adjoins their class-room. The department of civil engineering contains nearly 150 students and is the largest in the school. The state provides the means of obtaining a year's experience of practical work. Technologists generally spend four years from the age of 18 to 23 at this school, and have one year at practical work before entering it.†

Civil and mining engineers.

THE ROYAL MINING SCHOOL OF FREIBERG.

System of instruction at the school.

Of the numerous mining schools of Europe probably the Royal Saxon "Bergakademie" of Freiberg has trained the largest number of successful miners and metallurgists, and the title of M.E. (mining engineer) of that school is a guarantee of excellence and serves as a recommendation of the greatest value. The reason of this is obvious when we know that the system of instruction carried on here is a thoroughly practical one, so that the students are brought into actual contact with the operations on a large scale. The object of this time-honored institution is to give a complete scientific education both of a theoretical and practical character to young men intended for metallurgists or mining engineers. Admission to the school for Saxons and Germans is made dependent on having passed the Maturitäts examination of a gymnasium or first class Real-school, but foreigners are received without examination, provided they bring certificates of competence from some recognised scientific or educational institution, and this liberality on the part of the Saxon government has been largely availed of by many distinguished English and American metallurgists and mining engineers. Regular courses of study are laid down, extending over four years and differing according as

Courses of study.

* Report on Technical Instruction, vol. I, pp. 183-5.

† Ib., pp. 201—4.

the pupil desires to follow the mining or the metallurgical branch of the profession. Higher mathematics, descriptive geometry, spherical trigonometry, physics, chemistry, mineralogy, geology and mechanical drawing form the ground work of the studies, to which are added in the second and succeeding years the special subjects of mining and metallurgy and all their allied branches of science, taught by lectures, laboratory practice, by working and surveying in the mines and by practical metallurgical instruction in the smelting works of the Saxon state. The collections of mineralogical and geological specimens are most complete, and with the libraries and museums of mining machinery are open to all the students of the school. Many of the professors have been men of European fame—Werner, Plattner, and now Richter and Weisbach, are names known to and honored by all students of science. The lectures of Richter on the blow-pipe are unique, and those of Prof. Weisbach on mineralogy are most valuable. But the most important respect in which Freiberg excels is the practical experience which the students can gain in the operations of smelting conducted on a large scale in the government smelting works (the Müldnerhütte and that at Halsbrücke) as well as in those of mining by visiting the neighboring mines belonging to the Saxon government. As these mines now yield ore of only the poorest quality the operations have to be conducted with great care, and hence offer to the student of mining training of an exceptional character, while the number of metals present in the ore (gold, silver, copper, lead, bismuth, arsenic and antimony) and worked up at the smelting works afford a no less valuable one to the student in many branches of metallurgy. The cost of living in Freiberg, including the fees payable to the academy, need not exceed £100 per annum. The average number of students in training for the last ten years is: Saxons and Germans, 64; foreigners, 58. Freiberg does not however afford practical instruction in iron mining or smelting; the mining school specially adapted for the study of the metallurgy of iron is that of Leoben in Styria, under its veteran head, Prof. von Tunner.*

Equipment of the school.

Training by observation.

SCHNEIDER & CO.'S WORKS AT LE CREUZOT.

These magnificent works have been so frequently described, and a detailed account of them would occupy so large a space in this report, that we shall confine ourselves to a very brief statement of the facts bearing in the most direct manner on our enquiry. It is well known that these works situated far in the interior of France, derive a large portion of their supplies of iron ore—for the production of iron and steel of the most varied description—from Algeria, brought through Marseilles from Savoy and other distant places, and that a considerable part also of the fuel used has to be brought from the coal basin of St. Etienne. This is rendered possible by extremely low railway rates, less than three-eighths of a penny per mile on iron ores, or less than half of the average rates charged in the United Kingdom. Most of the powerful tools used at Le Creuzot in the construction of marine engines, in boring large guns and in planing armor plates, were formerly imported by them from England, but within the last few years these tools have been supplied by works in the east of France and in the French departments now annexed to Germany. The French engineering tools were formerly ill-designed and badly proportioned. Now English models are followed and the execution leaves nothing to be desired. A very small number of the heads of departments are former students of the great Parisian technical schools, several are from the Écoles des Arts et Métiers and many, including nearly all the foremen, have received no other instruction than that of the works and the excellent elementary schools founded and maintained by the firm. The head of the drawing office is one of these latter. The opinion of Mons. Henri Schneider was not favorable to the very high scientific courses of the Paris

Character of the works.

Training of foremen for the works in schools founded by the firm.

* Report on Technical Instruction, vol. I, pp. 206-7.

schools, except for men of remarkable ability and of the energy and common sense necessary to acquire workshop practice at a comparatively late period of life, and to avoid a pedantic application of abstruse theory to practical work. His estimate of the Écoles des Arts et Métiers, on the other hand, was very favorable. In several cases the firm had sent promising boys to those schools, but the workshop was held to be the true school for foremen. In the elementary schools connected with the works and carried on at the expense of the company great attention is given to geometrical drawing, and the work of the boys was surprisingly good. The elements of chemistry and physics are also taught. Night classes have been given up, partly because the instruction of the elementary day school was considered sufficient and partly in consequence of difficulties between masters and men during the times immediately preceding and succeeding the fall of the empire. The dissension which existed for a few years had however subsided to a great extent, and although the firm employ large numbers of miners near Montceau-les-Mines, where there had lately been troubles, the Creuzot men had not taken any part in them.*

TECHNICAL SCHOOLS IN THE UNITED STATES.

The following extracts are made from the report made to the British Royal Commissioners by William Mather, who at their request visited the United States and Canada in 1883, and reported on the subject of technical instruction :

SCHOOL OF MINES, COLUMBIA COLLEGE.

ourse of instruction.

The main object of this excellent school is to train students to become professors in colleges; also consulting, mining and civil engineers. It is however largely used by those who intend to pursue mechanical engineering in practice, such as the sons of manufacturers and machine constructors, and young men who desire to fit themselves for the leading positions in the great industries of the country. All the appliances are admirable, whether in classrooms, laboratories or workshops. This school is distinguished for the eminence of its professors and instructors, the liberality of its trustees and supporters, the completeness of its permanent appliances and the simplicity combined with elegance of its buildings. The spirit of the college is that of cheerful and intense activity in all departments I confined my inspection to the technical schools. The school of mines consists of a large block of buildings in which besides class room accommodation are the laboratories, shops and apparatus. Its system of instruction covers mining engineering, metallurgy, civil engineering, geology, analytical and applied chemistry and architecture. The students are required to be 17 years old and to pass an examination before entering the school, including, besides the ordinary studies of the high school course in the highest grades, simple mathematics, elementary physics and freehand drawing. The complete course extends over four years. The mining appliances are operative, and students conduct every process from the crushing of the ores to the assaying of the metal. The precious ores are chiefly treated, but general mining is thoroughly taught as a science. In civil engineering and surveying the method of instruction is very thorough. Field work enters largely into the occupations. Mechanical drawing is taught in all the stages up to machine designing. Hydraulic and mechanical engineering are studied in connection with the mining and civil engineering courses. Students in mechanical engineering especially have facilities for practice with tools in the shops. Boilers, steam engines, pumps and appliances for testing the strength of materials form part of the plant of the school. Chemical laboratories for qualitative and quantitative analysis are well equipped. . . A very important

Mining appliances.

Civil and mechanical engineering.

* Report on Technical Instruction, vol. I, pp. 266-7.

element in the practical application of the sciences taught in this school lies in the summer vacation work. The professors take out companies of students to mines, smelting works, iron works and machine shops to demonstrate their theoretical teaching by practice on the commercial basis. Students are encouraged to seek actual employment in various works during vacation and many do so. The fees for the two terms of the year are £40. Free students are admitted if properly qualified, and if their inability to pay is certified. About 300 students attend the school of mines.*

Summer vacation work.

CORNELL UNIVERSITY.

The technical school embraces agriculture, mechanic arts, civil engineering, mining engineering, freehand drawing, mathematics, astronomy, chemistry and physics. The farm of 120 acres is kept for experimental purposes and illustration of the science of agriculture. The students spend three hours on two days in each week in manual work on the farm. The mechanic arts are taught experimentally by the aid of a brass and iron foundry, blacksmith's shop, pattern making, machine tools and hand tools. In connection are the lecture room and the drawing room. Each student devotes two hours a day to actual work in the shops. Civil engineering is taught by lectures and field work, and practice in the chemical and physical laboratories is required of those receiving instruction in mineralogy, metallurgy, geology, physics and constructive engineering. Within the five years' course selections may be made of special studies according to the wants of the students. Electrical engineering has been added this year with ample appliances for its practical illustration. The mining engineering section has not yet become a separate department, though the necessary instruction is given. It is intended to establish a special school for this science with a small working plant. . . I have observed preparations being made to impart instruction in science, especially in chemistry and engineering, of a character eminently practical. Cornell is quoted as an example amongst those who are coming out of the old methods of what is termed "intellectual culture." The applied sciences are becoming recognised as forming as sure a basis for character and culture as the dead languages and higher mathematics for those who have to take part in developing and applying the resources of the country.†

Instruction in the mechanic arts.

Laboratory practice.

Mining engineering.

Value of the applied sciences as a course of study.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

The object is primarily to teach in the higher branches, mining, mechanical and civil engineering; secondarily, to give instruction in the mechanic arts to students who, coming from the ordinary public schools at 16 years old, may go through a two years' course in technical training before they enter upon actual employment. The students for the advanced course of civil and mechanical engineering come from the graduating classes in the high schools of the public school system, or pass a similar examination before entering upon the course prescribed for the students in this institute. The qualifications required are elementary chemistry, physics and simple mathematics. In other branches, the usual literary subjects of a high school; for the advanced course, the students have to enter for a period of four years. The institute is handsome in style and commodious in arrangement. It stands in the best part of the residential quarter of the city. There is a considerable quantity of land on which extensions can be made. The main building contains class rooms for lectures on the various subjects forming the curricula of the school. A large chemical laboratory divided into departments occupies the top floor of a new building, just erected for inorganic and organic chemistry and qualitative analysis. These laboratories are unsurpassed in the United States for convenience and completeness of apparatus and appliances. There is an excellent and well-appointed mining department, in which the rough ore is brought direct from the mines and treated by the

Objects of the institution.

Class-rooms and laboratories.

* Vol. II, Appendix p. 21. † Ib., p. 27.

students upon scientific principles, through all the practical operations of metallurgy to the final extraction of the pure metal. Crushing, smelting, reducing, refining, assaying are all gone through in proper order. The physical laboratory is a very complete department, with every variety of apparatus, most of which however may be regarded as a museum of philosophical instruments, inasmuch as the practical work is done by simple apparatus designed for the purpose by the professor and students. General physics, optics, acoustics, applied mechanics, electricity, hydraulics, history of the physical sciences, physical research, astronomy, etc., with the requisite mathematical instruction, form the subjects of a four years' tuition. The mechanical engineering department consists of suitable accommodation for lectures and mechanical drawing, allied with which are the chemical laboratory courses and physical laboratory instruction in steam, steam engines, dynamics, hydraulics, metallurgy and machine construction. The workshops are built some distance away from the main block. They are new and are fitted with appliances for machine construction, carpentry and pattern-making; moulding shop and cupola, tools, lathes; planing and shaping and drilling machines; forges, with all blacksmiths' tools; fitting shops, with vises, benches and hand tools. The work done consists in forming objects necessary for the construction of machines. No machines are made complete. This department is very practically arranged, and is efficient for the purpose of teaching the dexterous use of all tools for each branch of the mechanic arts. There is a department adjoining for testing the strength of materials of all kinds used in buildings and machine construction. The whole place is worked by steam-boilers and engines, upon which the students practice for instruction in economy and use of steam. The practical lessons are given for three hours on two days in each week. These shops are used constantly both by scientific students who are going through the whole course as well as by the students in mechanic arts who spend only two years here. The fees are £40 per annum. The school has £63,000 sunk in land and buildings, without apparatus. There is a fund of £30,000 from the "Grant of lands for the formation of agricultural colleges and schools of mechanic arts" in Massachusetts. One-third of the interest of this sum is devoted to the "mechanic arts" department of the school. This institution worthily enjoys a high reputation in America. Its graduates enter into the scientific professions and the engineering, mining and manufacturing industries without difficulty or delay. I have experienced this in the far west, among the mines, on railroad works, in machine shops and in the textile manufactories. Although the course of instruction extends to the higher branches of science, the practical application of knowledge is carried through each course by numerous experimental operations showing cause and effect. The whole spirit of the institution appears to create a connection between its work and the larger operations which the graduates will have to encounter in their future careers.*

The mining department.

Subjects of the four years course.

Mechanical engineering.

Workshops.

Maintenance of the school.

Spheres of usefulness for the graduates.

SHEFFIELD SCIENTIFIC SCHOOL OF YALE COLLEGE.

This was formerly the chemical laboratory of Yale college, but owing to the gifts of Mr. J. E. Sheffield of £100,000 and the land grant it has become a school for the diffusion of the sciences and for the training of young men for such pursuits as require proficiency in mathematics, physics and natural science. The courses of study most commonly followed are chemistry, civil engineering, mechanical engineering, agriculture, natural history, biology and preparatory studies for mining and metallurgy. The laboratories are supplied with every requisite for thorough experimental illustration, but no workshops are provided. The civil engineering course includes field work and practice. The mechanical engineering is taught by lectures and by a very thorough mechanical drawing course which is made to partake of the

A school for the diffusion of the sciences.

Courses of study.

* Vol. II, Appendix p. 28.

character of the drawing department of an engineering works. It is eminently practical. Professor Brush, the eminent principal, kindly devoted considerable time to the object of my visit and explained minutely the methods of instruction. The absence of manual work in this school gives a theoretical tone to the instruction. Provision is made however for frequent visits of the students to surrounding works. There are large collections of models, a technical library, and the museum and library of Yale college are open to the students. The noble benefactor of this school left another £100,000 on his decease. With further additions and extensions this institution will probably be made as complete as any in America as a technological school, without impairing its high character as a school of pure science and original research. The tuition fee is £30 per annum. There are 207 students.*

A substitute for manual work.

WORCESTER FREE SCHOOL, MASSACHUSETTS.

This technical school is especially designed and conducted to impart a thorough knowledge of the theory and practice of mechanical engineering. There are 255 students. The tuition is entirely free to students of Worcester county in the state of Massachusetts. The building is admirably adapted to its purpose. Class-rooms and works-hops are conveniently near, and the whole plan of the school is compact and commodious. The course of training extends over three and a half years. The students are divided into two sections, the ordinary undergraduate and the apprentice class. The former passes through the theoretical and practical instruction with the object of obtaining general knowledge of the science of mechanical engineering; the latter is supposed to learn a trade and to this end devotes 39 hours of each week to workshop practice. All students in the first year have to give a large proportion of their time to the shops. Later on shop practice decreases for the regular undergraduates. In the shops a certain number of skilled workmen are employed and they are engaged in manufacturing machines for sale. The students therefore work on actual machines in course of construction, with the intention of becoming competent mechanics while studying the theory of the profession. This school must be a great boon to the sons of working men who can afford to support them during the training period. The boys may not become highly skilled workmen, but entering at 16 and leaving at 19 they would go into engineering establishments as draughtsmen, or better as workmen, and obtain very rapidly all the larger practice to enable them to become excellent foremen. No student is accepted as an apprentice who is not actually of mechanical tastes and ability. As giving an opportunity to the sons of the poorer classes to obtain a mechanical training, this is the best school I have seen in America. Dr. Fuller is the able principal, and he is enthusiastic in his work.†

Purpose of the school.

The course of training.

WASHINGTON UNIVERSITY, ST. LOUIS.

As St. Louis has led the movement in the direction of kindergarten, so in connection with technical education this city has determined to prove that an intellectual training of the mind for any career is greatly assisted by manual exercises as part of a collegiate course. One department of the university is devoted to manual training. The complete collegiate course of study in the university is varied only to the extent necessary to enable those students who may desire to do so to spend a few hours per week in manual occupations. A commodious building contains carpentry, blacksmith, turning and fitting shops, well appointed with all the ordinary appliances for practical work. A boiler and steam-engine supply the power. The opportunity afforded by this school for technical training is generally sought by those who intend to follow mechanical pursuits. The workshop practice is excellent, and is taught by able instructors in each department. From four to six hours

The manual training school.

Conveniences for practical study.

* Vol. II, Appendix p. 30. † Ib., p. 30.

per week throughout the four years' course in the college are given to shop practice. Mining and metallurgy are taught by the aid of complete laboratories and a large collection of specimens. A graduate of the school of mines, Columbia college, is at the head of this department. I saw some forgings made by boys 17 years old which surprised me, and testified to the workmanlike training given in manual dexterity. The drawing classes are well conducted and the physical science exercises form a special feature in the course of studies. The fees are £20 per annum. The manual training school course taken alone is divided between the workshop and the classrooms. The students may enter at 14 years old, and only require a knowledge of arithmetic, geography, spelling and writing. The fees are £9 per term in the first year, £8 in the second year and £10 in the third year. Each term has 19 weeks. All the shop work is disciplinary. Special trades are not taught and no articles are made for sale. The work appeared to be well, rapidly and accurately executed. Dr. Woodward, the earnest and able principal of the school, has made industrial training a special subject of investigation and experiment. To him is due this excellent institution, the benefit of which has already been felt in encouraging the starting of such schools elsewhere.*

Mining and metallurgy.

Course and fees.

CALIFORNIA SCHOOL OF AGRICULTURE AND MECHANIC ARTS.

This is one of the most important schools of practical science in America. It is attached to the university and its students enjoy the benefits of a splendid library of 20,000 volumes, as also of a museum with a rare collection of specimens of minerals and natural history objects. The tuition is entirely free for both sexes through the university course, giving ample opportunity for higher education to all classes in the community. The situation of the university is beautiful, and all the surroundings are conducive to study and refinement of character. The technical school has for its chief aim the training of engineers and miners as well as agriculturists. Hydraulic engineering, which forms so large a part of mining qualifications in California, is prominent in the curriculum of the school. The operations in mining are illustrated by an operating plant, small but efficient. The workshop practice in mechanical engineering is given by the use of suitable tools. Drawing is taught through all the elementary stages, and finally in the last year is applied directly to original design and construction in civil, hydraulic and mechanical engineering. The chemical laboratories for qualitative and quantitative work and the laboratory for metallurgy and mineralogy are well appointed. The professors of this school are men who have acquired eminence in America. I was particularly pleased with the views of some of these gentlemen as to the importance of their instruction in its relation to the industries of California. Students are admitted at 16 years of age after passing examination. It was pointed out to me that young men came from the mines to study special subjects, and facilities were given to such students who could only remain a comparatively short period. The university has an income from the state of £50,000 a year. The value of grounds, buildings and apparatus is £161,000.†

Importance to students.

Chief aim of the technical course.

INFLUENCE OF TECHNICAL INSTRUCTION.

There can be no doubt that America owes much already to the schools which exist for technical education, though not actually helping the artisan class. Many hundreds of young men have been furnished from these sources for the superintendence of railway works, mining operations, machine shops and the textile industries, besides chemical works, glass manufactories, building operations, agriculture, etc. I have met in almost all the manufactories I have visited—from mining, iron and steel manufacturing, through all the mechanic arts up to watchmaking and sewing-machine manufacturing—evidences of the influence of the technical school.‡

Practical benefits of technical instruction.

* Vol. II, Appendix p. 31. † Ib., p. 33. ‡ Ib., p. 46.

On the practical utility of technical instruction and the character of such instruction many valuable suggestions will be found in the evidence of Sir Lowthian Bell, Dr. C. W. Siemens, M. W. Peace, Professor Huxley, Albert A. Jowett, Professor J. V. Jones and Professor Josiah P. Cook in the third volume of the British Commissioners' report. Other testimony.

THE MICHIGAN MINING SCHOOL.

Mr. Merritt, one of the Commissioners, visited the Michigan mining school at Houghton, in the upper peninsula, in August, 1888, and has made the following roport upon it:

The school was opened on September 15th, 1886. A student for admission must present evidence of having graduated at a high school or academy of good standing or he must pass an examination qualifying in arithmetic, algebra, book-keeping, plane geometry, physics and the elements of astronomy. Entrance qualification. Anyone may attend a separate lecture or course of lectures without examination. The whole instruction is free to residents of Michigan, the student merely paying for material used. The object of the school as designed by the legislature of the state, which supports it, is generally understood to be to turn out practical assayers, surveyors and draughtsmen, not to be a higher scientific class of mining school like Columbia college, but eminently practical in the above mentioned subjects. Object of the school. By reference to the course of studies it will be seen that surveying in particular appears to be very thoroughly provided for. Instruction was at first arranged for a two years' course, but a three years' course is now being arranged for. It was thought that by making the school free more local men, who could not otherwise afford it, would go in for a mining training and would be capable of assaying iron and other ores found in the state, and which are being tested all the time at the mines, and enable them to do the surveying and mapping required at the mines. Previous to the establishment of the mining school a less thorough course in the same direction was given at the state university; this has now been discontinued, but the mining school is classed as one of the departments of the university. The local mining men, though not all agreed as to the necessity of the school, have shown practical appreciation of it in that there are now the sons of four local mining captains at the school. Practical appreciation of the school. The collection and classification of a typical set of the minerals which occur in the state and the procuring and preservation of all statistics, scientific and other information, regarding the mineral resources of the upper peninsula, and all important discoveries and improvements in developing the same, are made part of the duty of this mining school, which must provide for a full report on the same each year from one or more of the persons engaged as teachers. A collection of mineral specimens. The school is managed by a board of control of six persons appointed by the governor of the state. The subjects of instruction are mathematics, drawing, surveying, mining and mining engineering, ore dressing, physics, mechanics and engineering, mechanical engineering, chemistry, assaying, metallurgy, crystallography, mineralogy, petrography, geology and economic geology. Subjects of instruction. A clause provides that every facility possible will be given to special students who desire to pursue some subject taught in the school, and by this provision it is hoped to aid practical miners who have but limited time; no arrangement however has been made for any special course to practical miners or prospectors, but they can attend any of the regular lectures they please. Special students. The state has appropriated $25,000 so far to meet running expenses of the school for the past two years and $75,000 for a building. At present quarters are found wherever obtainable for lecture rooms and laboratories, such as in the fire hall, rink, etc. Buildings and maintenance. The practical work, which is facilitated by proximity to the mines, consists of compulsory work for six weeks in mines, mills or smelting works and two weeks mining surveying in the mines. There are also voluntary visits to the mines, mills or copper smelting works on Satur- Lectures and practical work.

days during the third year, in addition to which there are lectures on mining, etc., with laboratory work 2 hours per week for 18 weeks, and 17 hours per week for 4 weeks; on metallurgy and assaying, 3 hours per week for 4 weeks and 18 hours per week for 18 weeks; and field and mining geology, 5 hours per week for 4 weeks. There are at present three professors and 29 students, including 7 special students; but the number of professors is about to be increased to five, and it is expected there will be 50 students in 1889. The professor in mining and engineering, R. M. Edwards, E. M., graduate of the Columbia school of mines, thinks that the chief advantage to a boy studying mining here is that he is in a mining atmosphere and hears mining talked on all sides, while at the Columbia mining school he only meets mining men as a rule when on the mining trip which is part of the course. At Houghton he considers that a boy insensibly picks up mining information all the time. It is also an advantage to be able to take the students out on Saturday to the mines during lectures. Mr. Edwards considers that a scientific course of training is essential as a foundation to mining and metallurgy. In a country where there was not a great deal of developed mining he believes it would be the better course to have the mining school attached to some established university than to attempt to start a separate school where there was some mining being carried on, provided always that there are visits to mining districts and working mines attached to the course as an essential part of it. The mining schools in New York and in St. Louis are considered the best in the United States. The former has one compulsory sojourn of six weeks at mines during a four months vacation following the third year, the course being four years. The mines chosen are either the lake Superior or the Pennsylvania coal regions. The St. Louis university compels three trips to and sojourns at mining regions during the course. The cost to the student of the Columbia school trip is from $60 to $100 as a rule. The board is generally about $8 a week at the mining centres to the students. A professor and two or three assistants usually accompany them. The director of the mining school, Mr. Wadsworth, was absent at the time of my visit, but I received every courtesy and assistance in my application for information from the treasurer, the secretary and Professor Edwards, and they expressed themselves ready and willing to give any further information by letter should you desire to apply to them. In conclusion I might say that the chief difficulty in arranging a course in a school of mines seems to lie in the fact that the first desire is for students thoroughly grounded in the elements of science, which is essential, but that it is found impossible to get a supply of the proper material, so that it becomes necessary to model all the first part of a mining and metallurgical course upon a school for scientific instruction, and after that is given to proceed with the practical mining and metallurgical studies. The course at the largest German and American schools of mines is four years owing to this fact.

Professors and students. *Advantages claimed for the school.* *Other mining schools.* *Difficulty of arranging a course.*

Albert Williams, jr., of the United States geological survey, was the first principal of the Houghton school, and in December, 1888, that gentleman furnished the Secretary of the Commission with the following statement respecting it:

Professors, and the course of study for students.

The Houghton school of mines was established as a strictly practical mining school, the aim of which was to give instruction to the sons of miners and others who wished to qualify themselves for actual work as surveyors, assayers, draughtsmen and general-utility men. The work of a mining superintendent requires experience, and the man to fill it must work up to it; he cannot hope to step out of a school into the office. Three professors were appointed when the institution opened, the first of whom had the departments of geology, mineralogy and mining engineering, the second had mathematics and drawing, and the third had chemistry and assaying. A year's

course was also provided for post-graduate study in metallurgy. Such a course is regarded as sufficient; the rest comes by experience and actual work. Students are taught surveying and field geology every afternoon in favorable weather, but this is only for a short season owing to the long summer vacation. About twenty students have been taking the regular course, and five of the older ones have taken the special course of the first year. The sons of mining captains and superintendents compose the class almost entirely. Many of these cannot get a training at all unless it is provided for them at this school. Besides the scientific course they get the advantage of work in real life. Machinery can best be studied with a machine in operation. This idea generally prevails in America, and schools working on this line are now established at Rapid City in Dakota, in the heart of the Black Hills mining country; at Golden in Colorado, in the vicinity of the gold mines and within range of silver and other mines; and at Rolla in Missouri, near the lead and zinc mines. In my opinion mining operations cannot be carried on without the preparation afforded by these schools, as under the American system the mining superintendent ought to be master of all parts of the work; he ought at least to know that the work is going on right. At Michigan many of the students would be capable of undertaking draughting and surveying, and there were openings for them to work during the summer vacation while I had charge of the school; but assaying, especially for iron, requires a longer course. The new building contains a pretty full apparatus. At Cornwall, in England, night schools are established which are very good as far as they go, but a man cannot do drawing after working with his hands all day. In Michigan, in the copper and iron mines, this kind of training is highly prized, and the miners there are generally Cornishmen. Farther west, from Colorado to the coast, the skilled men are generally Americans. Students from Freiburg who come here find that they have to learn the occupation over again as the method of mining here is different from that pursued in Germany, being in the latter country more careful of small savings. In Germany the mines are generally government property, and the aim is to give employment to the people rather than to make money. In America the aim is to get the ore out of a mine as fast as possible and then begin elsewhere.

The American idea of mining schools.

Night schools.

Mining in Germany and America.

AMERICAN AND FOREIGN MINING SCHOOLS.

In his address as president of the American Institute of Mining Engineers in 1886 Prof. R. H. Richards, of the Massachusetts Institute of Technology, gave a synopsis of American and foreign colleges which are either pure mining schools or colleges which provide a course of mining instruction. From this address the following information is taken:

Colorado School of Mines has a lecturer in metallurgy. The admission age is seventeen years. Offers two courses, mining engineering and metallurgy; four years for each. Degree in mining E. M.; degree in metallurgy Ph. B.; after two additional years of work an advanced degree of Ph. D. Requires a vacation memoir each year, and during the term visits are made to smelting works and to regions interesting geologically. "The one-year course of assaying was established to supply a demand for assayers of a better grade than commonly found in the mining camps." There is also a one-year course in surveying, and for both of these courses diplomas are given. "About half the students take the four years' course." The school aims "to supply in some measure the lack of a state geological survey." Excursions made weekly to points of geological interest. Three excursions made annually to mining and smelting points.

Colorado school of mines.

Columbia College has a school of mines with seven courses, one of which is in mining and one in metallurgy. A professor of mineralogy and metallurgy. A professor of engineering who lectures on mining engineering. A professor (adjunct) of surveying and practical mining. Has a mining

Columbia school of mines.

laboratory. Has prominent summer schools in surveying (required), in mechanical engineering (voluntary), in practical mining (required). Students enter at eighteen years. The course is four years with degree of E.M. After a year's additional study, Ph.D. Mining laboratory contains sample grinder, three-rockbreakers, rolls, jigs, three-stamp battery, amalgamated plates, Frue vanner, Golden Gate concentrator, Imlay vanner, amalgamating-pan, settler, lixiviation tubs, calcining reverberatory furnace and pot furnaces. About one hundred hours devoted to mining laboratory. Summer schools: End of the first and three years, memoirs required. The same summer school for study of mechanical engineering in machine shops, voluntary. End of the third year, summer school for systematic study of practical mining and underground surveying for six weeks, required. End of fourth year, practical work in machine design contemplated.

Scientific department of Lafayette college.

Lafayette College includes the Pardee scientific department which offers five courses, one of which is mining engineering. It has a professor of mining and graphics. It gives practice in mine surveying during the term, and is near mines and metallurgical works which the students have the opportunity of visiting. Entering age not specified. The course is four years with the degree of E.M. Students in the junior year are required to spend several days at the mines at mine surveying, and to write a memoir upon observed mining operations; and in the senior year one or more memoirs are required on metallurgical processes as a result of investigations at the works.

School of technology at Lehigh university.

Lehigh University has a separate school of technology with four engineering courses. One of them is mining and metallurgy. It has a professor of mineralogy and metallurgy, and a professor of geology and mining. Mine surveying is taught in mines during the term. Entrance age, sixteen years. Course, five years. At the end of the fourth year the degree given is B.S. At the end of the fifth year the degree is E.M. Opportunity for local excursions throughout the school year. A practical course in mine surveying is given for three or four days during the term, fourth year.

The Massachusetts institute of technology.

Massachusetts Institute of Technology is a school of technology with nine courses. One of them is a course in mining engineering, which can be taken with either the engineering, the geology or the metallurgy more pronounced. Has a professor of mining and metallurgy, also an instructor in mining and metallurgy and two lecturers in metallurgy. Has a prominent mining laboratory. Has voluntary summer school. Students enter at seventeen. The course is four years. Degree of B.S. Mining laboratory contains sample-grinder, rock-breaker, rolls, sizing sieves, separator, jigs, convex buddle, three-stamp battery, amalgamated plates, Frue vanner, four amalgamating-pans, settler, ball-grinder and amalgamator, four Morrell automatic agate mortars, two sets lixiviating tubs, 40 gallons and 8 gallons respectively, dynamos for depositing, lead-smelting, reverberatory water-jacket cupola, melting-kettle, cupellation-furnace and heat-recuperative furnace combined, copper refinery, calcining reverberatories for 200-pound and for 20-pound charges respectively, pot furnaces, roasting-kiln, forge. Fifteen weeks of eight hours each and fifteen weeks of twelve hours each devoted to mining laboratory. Summer school: At the end of the third or fourth year examinations of mines and works, for three weeks. Attendance voluntary.

School of applied science at McGill university.

McGill University has a separate school of applied science with four distinct departments. One of them is mining engineering. It has a professor of chemistry and lecturer on assaying and mining. The entrance age is usually sixteen or seventeen years. Frequent geological excursions are made. The course is four years with degree of B.A.Sc. After three years more the degree of M.A.Sc., Master of Applied Science.

Missouri University has a school of mines and metallurgy at Rolla, with a professor of civil and mine engineering and graphics, also a professor of analytical chemistry and metallurgy. Has excursions to metallurgical works. The entering age is not specified. There are two years of preparatory and three years of technical training. The degree is that of M.E. Excursions are made during the term to mines and to iron, lead and zinc works, and extensive field practice is given in surveying. Missouri school of mines.

Universty of California has five scientific colleges; one of them is a college of mining, with a professor of mining and metallurgy and an honorary professor of mining. Students enter at sixteen. The course is four years with a degree of B.S. After three years more, at least one of which is spent in graduate study, and at least one other in outside practice, the degree of E.M. or E.Met. is given. Has mining and metallurgical laboratories just erected, which are now being equipped so as to contain a complete plant for sampling, concentrating, milling, roasting and leaching the gold and silver ores of California. The present plant consists of ten-horsepower dynamometer, Dodge crusher 6 by 4, Krom fine crusher, Krom steel rolls, California battery of three stamps 500 pounds each, Sturtevant 6-inch pulveriser, Frisbee & Lucop 12-inch mill, set of shaking screens, Krom air-jig, set of Spitzkasten and Spitzlutten, Frue vanner arranged with side and end shake, amalgamating-pans, settlers, calcining reverberatory furnace and leaching tubs. Space is available for smelting outfit whenever it is considered advisable. Summer school: Excursions for mining and railroad surveying during the summer are open to all students of the mining course and are largely attended. Excursions to mines, smelting works and other industrial manufacturing establishments are arranged for all students in mining and metallurgy; the time given to them ranges from a few days to ten weeks in the summer. California college of mining.

University of Illinois has a college of engineering with four schools, one of which is a school of mining engineering which was reorganised in 1885 and is not fully equipped. There is a professor of mining. A mining laboratory is contemplated. Age at entering fifteen years; *i.e.* students may enter at fifteen, but are advised not to do so until eighteen years of age. The course is four years with the degree of B.S. One year's post-graduate study entitles to the degree of E.M. Frequent excursions and theses requiring studies at the mines. Illinois school of mining engineering.

University of King's College is at Windsor, Nova Scotia. Was founded in 1802. Has a course in civil engineering, with alternative of mining. It has a professor of chemistry, geology and mining. It offers summer excursions. Entering age is not specified. The course is three years, with the degree of B.E. King's college, Nova Scotia.

University of Michigan has a professor of mineralogy, economic geology and mining engineering, and a professor of metallurgy. Students enter at sixteen. Length of course not specified, but covers in fact four years. The degree of B.S. is given when the necessary number of courses has been satisfactorily finished. A degree in mining engineering is given after post-graduate course. In this university many students who are candidates for degrees in arts, philosophy, science or letters pursue mining and metallurgical subjects. Mining engineering at the university of Michigan.

University of Ohio has seventeen courses, one of which is mining and metallurgy. It has a professor of mining and metallurgy. Entering age not specified. The course is four years, with the degree of M.E. Total number of graduates from the college 75; from the mining course 9. Students now in the college 323, of whom 14 are studying mining. Memoirs are required which necessitate visits to mines on the part of the students. Mining and metallurgy course at the Ohio university.

Towne scientific school in the Pennsylvania university.

University of Pennsylvania includes the Towne scientific school, with five courses, one of which is in metallurgy and mining. It has a professor emeritus of geology and mining, a professor of metallurgy and mineralogy, and a lecturer on geology and mining. A mining laboratory is contemplated. There is a summer school in mine surveying; there are also geological excursions. Entering age depends on proper preparation only. The course is five years; two years preparatory, three years technical work. The degrees are B.S. and E.M. In the third year four excursions of one day each, one excursion of two weeks. In the fourth year four excursions of one day each, one excursion of two weeks. In the fifth year three weeks in the coal mines and six days in metallurgical works.

Mining course at Wisconsin university.

University of Wisconsin gives a course in mining engineering, also one in metallurgical engineering. Has a professor of metallurgy. There are excursions to metallurgical works. Entering age sixteen. The course is four years. Degrees, B.Met.E. and B.M.E. Second degrees given on examination only, and after at least one year of study and practice, Met.E. and M.E.

Polytechnic school in St. Louis university.

Washington university, St. Louis, has a polytechnic school with four courses; one of them is mining and metallurgy. It has a professor of mining and metallurgy; has a mining laboratory in preparation for next year; has a prominent summer school of surveying, mining and metallurgy, attendance on which is a requirement. It has excursions to mines and works. Students enter at sixteen. The course is four years with the degree of B.E. After one additional year of special study the degree of E.M. is given.

Other schools in America.

There are three other schools of mines contemplated in the United States: one at Houghton, Mich., which expects to open its doors in September, 1886; one at Rapid City, Dakota, named the Dakota school of mines, for which a portion of the funds needed have already been appropriated; and at the Rose polytechnic school, Terre Haute, Ind., "a department of mining engineering is contemplated but not yet organised."

Science college at Birmingham, England.

Mason science college, Birmingham, prepares for examinations for degrees from London university. Has professors of chemistry and metallurgy, geology, engineering and mining. Gives courses in metallurgy and applied geology, with summer field work and excursions. Gives courses in mining for the title of Mining Associate, and a certificate of competency for colliery managers and proprietors; also evening lectures to working miners.

Owens college, Manchester, England.

Owens College (Victoria university) Manchester, has in addition to professors of mathematics (pure and applied), physics and chemistry, a professor of engineering, a professor of geology, a lecturer in metallurgy and a lecturer in mineralogy. New and well furnished laboratories have just been completed for geology and mineralogy; a large engineering laboratory is in course of construction and a small laboratory is provided for the lecturer in metallurgy. The college gives a certificate in engineering on the completion of a three-years' course; and a certificate in "applied geology and subjects preparatory to mining" after a two-years' course, which "is not intended to supersede the practical training which is to be obtained in the office of the mining engineer or in the mines." This course comprises instruction in chemistry and physics as well as in engineering, geology and mineralogy, and includes field work and visits to mines. The Victoria university gives its degree of B.Sc. in the several groups (amongst others) of engineering, experimental sciences and geology.

Swedish school of mines at Stockholm

The Swedish mining school was established in 1821 in Falun. In 1869 it was removed to Stockholm, and incorporated with Kongl. Tekniska Högskolan. Two or three years are given to preparatory studies and one year to strictly technical studies, or to the application of metallurgy or mining. The school for the last year offers eight courses in mining, metallurgy and assaying

In the first year the studies are common to all the pupils of K. Tekniska Högskolan, which embraces five branches or departments, viz., for mechanical engineers, chemists, civil engineers, architects, and metallurgical or mining engineers. In the metallurgy of iron and in mining an excellent summer course is given. Professor Richard Akerman writes me: "The second of May I take the students of the third and fourth years of the course to an iron works, where we remain for six weeks, during which they manage for themselves a small blast furnace of their own and work in charcoal hearths, etc. After that we visit some other iron works, and then begins the practical training in mining at the mine, where the professor of mining takes care of the students for about three weeks, whereupon the professors of mining and metallurgy for about a forthnight travel with the pupils to different mines and works. Of what they have seen during these travels the students have to elaborate descriptions until the beginning of October, during which month they are examined."

Mining academies in Austria.

There are three Austrian mining academies. Those of Leoben and Przibram (belonging to Austria proper) are for German-speaking students. The school of Schemnitz (Hungarian) is intended for the Hungarian population of the empire. One feature characteristic of the Austrian mining schools is the great importance given to the study of mining and metallurgical machinery. To each of these a special series of lectures, combined with practical designing, is devoted.

Mining schools in Prussia.

Prussia has three schools where mining and metallurgy are taught—the academies of Clausthal and Berlin, which are devoted entirely to these branches, and the polytechnicum of Aachen (Aix-la-Chapelle), which has a mining department. A difference is made between private students and those who are candidates for government positions. A government student must be a graduate from a first rank Real-schule or gymnasium. He is then obliged to take one year's practical course in mines under the direction of the head government mining official of the district where his application has been made; after this he must study three years, one of which at Berlin. The conditions of admission for non-government and special students are about the same as those of Freiburg. Clausthal's special features are the geology, the deep mines, the large concentration works of argentiferous lead and copper ores. Fifty-three Americans have studied at the school; eight have graduated. Aachen's specialty is the large iron, coal and zinc industry in its neighborhood. Five Americans have studied at the school since 1874; one American is now at the school. Every Saturday is in both of these schools devoted to systematic, practical study in mines or works.*

SCHOOLS OF MINES IN NEW ZEALAND.

Origin and objects of the schools.

Schools of mines have been formed on the various gold fields with the view of affording technical instruction in subjects relating to minerals, mines and mining. The distinguishing feature of the scheme is that it brings the instruction to the centres of the mining communities on every gold field and coal field in the colony, and thus enables the miners to attend the classes in the evening while carrying on their ordinary work during the day. The scheme had its origin in Lawrence, Otago, in November, 1884, when at the request of Mr. J. C. Brown, M.H.R., Professor Black of the university of Otago delivered three lectures on the chemistry of minerals to the Lawrence Athenæum and Mining Institute. Encouraged by the enthusiasm created among the miners, an extended course of lectures and practical classes for the testing of minerals were immediately organised by the Lawrence Athenæum committee and carried out with great success. The Hon. W. J. M. Larnach, C.M.G., coming then into office as minister of mines for the colony and recog-

* Transactions of the American Institute of Mining Engineers, vol. xv., pp. 322-331 and 810-13.

nising at once the directness and practical character of the instruction thus given, the warm reception it was meeting with on the part of the miners and the great advantages which if properly managed it could not fail to bring to the mining community, took up the movement at this point, extended it to the whole colony and directed and fostered it into what has now become an important colonial institution. The scheme does not aim at imparting an exhaustive course of instruction in the subjects of study. This is left for the Otago school of mines and the university colleges, which the few alone are able to attend. It aims rather at giving the miners an elementary but at the same time practical acquaintance with a few of the branches of science relating to minerals, such as will be of the most advantage to them in their daily work and through them to the colony at large. The subjects which are taken up in such a course are the following: (1) geology, (2) mineralogy, (3) chemistry as applied to minerals, (4) the testing of minerals by wet processes, (5) assaying, (6) metallurgy or the extraction of metals from their ores, and (7) blowpipe. Provision is also made under the scheme for classes in mining, surveying and mine engineering. It is intended that these classes when fully equipped will qualify intending mine managers for passing the examination that will be required of them by a recent act of parliament. The results expected from the scheme, and indeed already attained to a considerable extent, are such as the following:

The movement extended to the whole colony.

Scheme of instruction in the schools and results looked for.

(*a*) Miners in every mining district will be made familiar with all ores of any value; they will be able by simple tests to identify ores and ascertain for themselves what metals they contain.

(*b*) Miners will be able to assay ores and minerals of every kind, to find out their richness or what proportion of metal or other valuable substance they contain; to find out for example how many ounces of gold or silver per ton a stone contains, what percentage of mercury, copper, tin, lead, antimony, iron, zinc, etc., the quality of coal, oil-shale, limestone, building stone, etc.

(*c*) Miners will be familiarised with the acids, alkalis and salts, with the action of these chemicals on gold, silver, mercury, copper and the other metals, and with their use in the treatment of copper plates, sickened mercury, testing ores and generally in gold and silver-saving processes.

(*d*) Miners will be able to make their own sodium amalgam at a small fraction of the cost of the imported article and will thus have control over its quality, and having a practical acquaintance with its action under all conditions they will be in a position to experiment in an intelligent manner on its use as a mercury-cleaning and gold-saving appliance.

(*e*) Miners will be instructed in the most simple and effective processes for cleaning dirty gold from such impurities as rust, lead, zinc, tin, iron or an undue proportion of copper or silver, etc., so as to make it saleable at its proper price.

(*f*) Miners will also be able to assay their gold or bullion so as to ascertain its fineness and commercial value. This is specially important on a new field where the quality of the gold is unknown, or on a field like the Hauraki peninsula where the proportion of gold and silver in the bullion varies widely.

(*g*) Miners will have by means of practical experiments, diagrams, descriptions and explanations an intelligent acquaintance with the objects, principles and conditions of roasting and smelting processes, the various kinds of furnace, fluxes, oxidising and reducing agents, the different effects brought about at various temperatures, the different chemicals employed in the furnace and in the vats, especially in recent silver smelting processes, and the part which electricity may be made to play in the treatment of ores.

(*h*) Miners will also by means of lectures and the current periodical literature on mining subjects be put in possession of the most recent intelligence as to improved processes in use in other countries as well as in different parts of the colony itself.

TEACHING STAFF OF THE SCHOOLS.

The carrying out of the scheme has hitherto been intrusted to Professor Black and a staff of seven colleagues and assistants. Their qualifications for the work are as follows: Qualifications of teachers

(1) James G. Black, M.A., D.Sc., is professor of chemistry, metallurgy and assaying in the university of Otago and Otago school of mines.

(2) Alexander Montgomery, M.A., with first-class honors in chemistry and physics (London examination), is an alumnus of Otago university and school of mines, and was assistant to Professor Black for two years in the chemistry classes of Otago university.

(3) Thomas F. Fenton, late mine and battery manager, mine and mineral viewer and assayer, has completed one year's studies in chemistry, metallurgy, assaying, mining and blowpipe in Otago university and school of mines.

(4) Victor McLymont is a third year's student in chemistry, first year's student in mining, assaying, metallurgy and blowpipe and ex-assistant to Professor Black in the chemistry classes of Otago university and school of mines.

(5) Thomas Buteman is a fourth year's student of Otago university and school of mines. He has gone through a full course of studies, practical and theoretical, in chemistry, metallurgy, assaying, mining, mineralogy and blowpipe.

(6) Robert Irvine is a second year's student in chemistry and first year's student in assaying, metallurgy, mining and blowpipe in Otago university and school of mines.

(7) Adolph Hamann has completed a full curriculum in the Otago school of mines and has distinguished himself in chemistry, assaying, metallurgy, blowpipe and the mining and mineralogy classes.

(8) William Goodlet has been laboratory assistant to Professor Black for six years in the chemistry, assaying and metallurgy classes of the Otago university and school of mines.

Arrangements are also being made for securing the valuable co-operation of Professor Brown of Auckland college, and probably of Professor Bickerton of Canterbury college.

Professor Black besides taking the general supervision of the scheme all the year round, devotes the six summer months (November to May) exclusively to his duties under it, dividing his time pretty equally between the different districts of the colony. Mr. Montgomery is occupied all the year with the Thames district. Messrs. Buteman and Irvine were during the year 1886 engaged for only six weeks conducting assaying and blowpipe classes in the Rees', Skipper's and Macetown reefing districts. All the other members of the staff are engaged for only the six summer months and have been located for the present year as follows: Mr. Fenton in the Westport, Reefton and Lyell districts, Mr. McLymont in the Ross, Hokitika, Kumara and Greymouth districts, Mr. Hamann in the Lawrence, Cromwell and Naseby districts. In placing the members of the teaching staff care is taken that men of special acquirements are appointed to districts where their particular knowledge will be most serviceable. Employment of instructors.

CONSTITUTION AND ESTABLISHMENT OF SCHOOLS OF MINES.

The establishment of a school of mines in any mining district is left to the action of the miners themselves. When they desire to share in the advantages of the scheme they form themselves into an association or institute or club which for the sake of uniformity is generally called a school of mines. They fix for themselves an annual subscription varying from 5s. to £1, entitling to membership, and with the funds thus collected are procured the necessary chemicals, crucibles, balances and other appliances for carrying on their experiments. These are procured from the government stock at the Local action in organising schools.

rate of about two pounds' worth of chemicals for every pound subscribed. The association constitutes itself, elects its own office-bearers and makes its own rules and by-laws. Wherever such association or school of mines exists arrangements are made to send one or more members of the teaching staff to conduct practical testing, blowpipe and assaying classes and to deliver a course of lectures on some mining subject for a period ranging from a fortnight to ten or twelve weeks in each year according to the importance of the district. Professor Black also visits every district once a year to advise and assist the local committees in their work and to conduct classes and deliver lectures which are open to the public during his stay. He also, as well as all the members of his staff, tests and assays free of charge such minerals as are brought by the miners or forwarded to him at the university laboratory, Dunedin.

CHARACTER OF THE TEACHING.

The character of the teaching and the reception it meets with on the part of the miners may be gathered from the following extracts from Professor Black's report to the minister of mines, dated 24th May, 1886:

The work carried on in the classes at the Thames was of the following nature:

Blowpipe classes.

1. Mr. Montgomery opened his blowpipe class every morning at 8 o'clock, taking the students in two relays up to 11 or 12 o'clock and again another relay from 6 to 7 in the evening. In these blowpipe classes, which I regard as an important feature of the programme. Mr. Montgomery seated his students along each side of a table about 25 feet in length. He provided each student with a stout candle, a piece of wood charcoal, a small and inexpensive assortment of chemicals in the form of dry salts and other reagents, and a blowpipe. The supply of blowpipes however ran short owing to the large number that joined the class, but the students very soon provided themselves with that requisite from various sources. Furnished with these appliances Mr. Montgomery took his students through a preliminary course of blowing, practising them in the different kinds of flame—oxidising flame, reducing flame etc.—and here he was greatly aided by the efficiency of many of the students who were adepts in the art. He then guided them through a long course of blowing beads in the loop of a platinum wire from the powdered ores of different metals, showing them how to identify the metal from the color of the bead in the various fluxes. Mr. Montgomery also instructed and exercised his class in the art of heating metallic compounds with and without oxidising and reducing agents, and fluxes in dry glass tubes and on charcoal, and showed them how to distinguish the substance on trial by the results obtained. The energy and success with which these students entered into these blowpipe experiments were quite in keeping with their enthusiasm and perseverance in the other classes.

Assaying.

2. Mr. Fenton, who joined the teaching staff as assayer in Auckland, opened his class for assaying metallic ores every morning at 9 o'clock and conducted with his students assays every day from 9 a.m. to 5 p.m. on the ores of gold, silver, lead and tin. Being in some difficulty about necessary furnaces, Mr. Dunlop of the Golden Crown battery built a melting and assay furnace in the battery and gave the use of it free of charge to the class, supplying them as well with various other appliances required for carrying on the fire assays. In Mr. Fenton's classes as in all the others the men themselves took a practical part in the work. He had them engaged in grinding and sifting the ores, weighing them, weighing out the proper fluxes for the different kinds of ore, mixing the fluxes with the ground ore, charging the crucibles, heating them in the melting furnace to the required temperature and for the proper time, pouring out the molten metal into the ingot moulds, detaching the slag, hammering and cupelling the resultant buttons of metal, weighing the bullion and finally separating the silver from the gold, washing, drying and weighing the latter and calculating the results. In all these operations the men took a most intelligent interest and worked at them with such success that a very large number of men on the Thames can now assay their own ores with quite sufficient accuracy for their own purposes. The direct advantage to the miners of being able to do this will be seen when it is stated that the silver in the silver-bearing stone of Waihi and Karangahake does not exist in the stone in the state of metallic silver, but chiefly as the grayish-black sulphide and the variously colored chloride, and in these states of combination it is not visible at all as silver. Most of the gold also in the silver bearing ore exists as a blackish sulphide of gold, probably in combina-

tion with sulphide of silver, and thus escapes the notice of the miner who is prospecting on the old lines. It is only when the gold and silver are brought out either by the fire assay process or by the wet chemical processes that the value of the stone is known. Much stone on the Waihi and Karangahake containing gold and silver worth £10 to £100 per ton of stone has been overlooked for years for want of a little of this kind of knowledge. I have heard since my visit to the Thames of several instances of large quantites of stone showing to the eye neither gold nor silver being taken up by members of Mr. Fenton's assaying class and turned rapidly to their own advantage. A practical acquaintance with the methods of testing stone puts the mining prospector in a position to profit directly by his own discoveries instead of having to get sample after sample tested by the professional assayer for a fee which he can in many cases ill afford, besides subjecting himself to tedious delays, long journeys, loss of time and the risk of having someone else better informed in the meantime jumping his claim. I look on a practical knowledge of the process for assaying silver and gold bearing stone as an incalculable boon to the miners on the Hauraki peninsula, and a boon that in the interests of the colony the government would do well to provide.

3. My own testing classes were held in the morning from 9 to 12 o'clock and again in the evening from 7 to 9 o'clock. In these classes I was very efficiently assisted by Messrs. McLymont and Goodlet, and by Mr. Montgomery when he was not otherwise engaged. In these classes also the students themselves carried on the various operations. The students were arranged around several large working tables, provided with stands of test-tubes, filtering appliances, spirit lamps, solutions of metallic salts and the various acids, alkalis and other chemicals required in the testing processes. In the first part of the course they applied the proper tests under my guidance to solutions containing only one metal at a time. In this way we dealt with solutions of gold, platinum, silver, lead, mercury, copper, cadmium, arsenic, antimony and tin, iron, nickel, cobalt, manganese and zinc, also in some cases barium, magnesium and calcium. Having mastered the tests for the metals in solution one at a time we proceeded with the processes for identifying the metals when several were present in the same solution. The time at our disposal however at one place did not admit of a thorough study of this branch of analysis, and we had to leave it to the more leisurely attention of the permanent staff in the school of mines. We then entered on a very fascinating and important branch of analysis in which we dealt with the ores themselves, grinding them in the mortar, treating the powder with the proper acid (nitric, muriatic or sulphuric) or mixture of acids (generally aqua regia, a mixture of strong nitric acid and strong muriatic acid), boiling to dryness or otherwise, stirring up the residue with water so as to get a water solution of the metal and then applying to this solution the proper tests in the proper order till the metal was discovered. When the stone contained, as was generally the case, more than one metal the processes for identifying these in each other's presence were gone through, thus bringing to bear all the knowledge practical and theoretical acquired in the earlier parts of the course. In this way we analysed minerals containing the following metals: gold, silver, lead, mercury, antimony, platinum, zinc, copper, iron, nickel and managnese. We also tested in the same way scheelite— worth from £20 to £35 per ton and occurring in various parts of Otago from Naseby to the head of lake Wakatipu—limestone, wolfran and the various silicates. We also extracted tin from tinstone by fusing it out with the proper fluxes and afterwards subjected it in solution to the various tests for that metal. In some of the classes we also examined ores containing the metals named above, quantitatively to determine the percentage of metal they contained, also coal of various kinds to determine the percentage of water, ash, gas and fixed carbon. During our prolonged stay at the Thames we had time to go through pretty nearly all the work described above, but at the other centres visited it was quite impossible in the time at our disposal to go through more than the simplest part of so large a programme. At every place I visited during the session under report as well as on my tour round the southern gold fields the year before, the attendance was almost invariably increasing during my stay, and my feeling was on the eve of leaving many a gold field that I could well stay there for years and find plenty to do among the mining classes all the time. The men are not only most intelligent and very well informed—in many cases on subjects altogether outside their own pursuits—but are as a rule to which I have not found any exceptions, of a genial, straightforward and kindly disposition, which makes it a positive pleasure to have any dealings with them.

Testing classes.

Attendance at the classes.

Subjects of lectures.

4. My own lecture was delivered usually from 9 to 11 or 11.30 p.m. and always closed the day's proceedings. The subject of the lecture was one or other of the following course :

How quartz reefs were formed.
How gold came into the reefs.
How other metals came into the reefs.
The chemistry of gold.
The methods of testing and assaying gold-bearing stone.
The chlorination process for extracting gold from iron pyrites.
The conditions to be observed in the roasting of metallic sulphides.
The Lamonte furnace.
The ores of silver, and the processes for the extraction of silver from its ores.
The processes for assaying and testing silver bearing stone.
Copper and its ores.
The extraction of copper from its ores.
Tin : its occurrence an l extraction from tinstone.
Lead and antimony : their ores and metallurgy.
Iron and its ores.
The smelting of iron ores.
Mercury : its occurrence and the methods of extracting it from its ores.
Sodium amalgam: its manufacture, properties and uses as a gold-saving appliance.
Nitric acid and muriatic acid : their manufacture, tests of their strength and purity and their properties and uses for testing ores, and
On the gold fields generally.

Interest in the subjects of study.

I have been often astonished at the patience with which the miners would sit for three or four or sometimes five hours listening to a lecture on some of the above subjects. They were always freely illustrated by experiments, but it was evidently not these but their intelligent interest in the subject of lecture, and their ability to follow it clearly in all its essential details, that kept the men on their seats to its close. A look at the above list of subjects of experimental lectures will show how well they are suited to an intelligent mining audience, and it is to such subjects as these that I wish the attention of the teaching staff of the chemistry department of the gold fields schools of mines to be directed.

At the Thames Mr. Montgomery delivered during the week three of his lectures on gold saving appliances, and I closed the classes there by two lectures on the treatment of silver ore and gold bearing tailings on Thursday and Friday evenings before audiences larger, stronger, more enthusiastic and more keenly interested in the subject of lecture than ever they had been before. Indeed my experience everywhere was that the longer we stayed the more intense did the interest become, the more the miners knew the more they wished to know. So much was this the case at the Thames. Karangahake, Te Aroha, Waiorongomai and Coromandel as well as on the west coast and southern gold fields that it was quite depressing to have to leave such crowds of intelligent men in place after place, all eager to get further information and practice in the methods of testing the ores.

From the Thames we all proceeded by steamer with warden Kenrick to Coromandel on Saturday the 12th December, and lectured there the same evening. Mr. Cadman, M.H.R., had been for weeks before our arrival in constant communication with Mr. Kendrick and myself about our visit, had spread among the miners information about our doings on the Thames and elsewhere, and had made all necessary arrangements for the success of the classes. The result of all this preparation was that we found on the night of our arrival a crowd of about 180, nearly all miners, awaiting us in the schoolroom. The large room was crowded to overflowing, and many could not even get standing room within the building. The testi g class was at once formed and continued under my direction and that of Messrs. Montgomery and McLymont from 7 p.m. to 9.30 p.m., when Mr. Cadman took the chair and I lectured till 11.30 p.m. on the formation of quartz reefs and the introduction of gold into them. Messrs. Montgomery and Fenton opened their blowpipe and assaying classes on Monday morning at 8 o'clock and continued all day, with several relays of students, the men themselves as usual taking a direct and active part in all the operations. Mr. McLymont had during Monday and Tuesday full charge of the testing classes until 7 p.m., when I took charge and continued for two hours with the metallic ores, following each evening with a lecture till 11.30 p.m. on some subject connected with gold saving processes.

After spending four days at the Thames lecturing and conducting classes, I proceeded with Mr. Fenton and Mr. Goodlet to Karangahake, about fifty miles in-

land, leaving Messrs. Montgomery and McLymont in charge of the Thames classes. Warden Kendrick, who as usual had made all necessary arrangements, accompanied me to Karangahake and presided at the first meeting, which was attended by 150 miners As there was no room at Karangahake large enough to accommodate such a crowd Mr. R. K. Davis put his Lamonte furnace building at our disposal. This building was in course of erection and nearly finished, and through the efforts of Mr. Haslett, the foreman, it was soon put in a condition suited to the purposes of the classes. Next day about 30 of the miners took a half holiday to go through the assaying processes with Mr. Fenton. Mr. Smith, the professional assayer at Karangahake, very kindly put his plant at our disposal for that purpose. This was really a kindness as we were utterly destitute of balances and crucibles, and it is an unheard-of thing for an assayer to expose his delicate balance and fine crucibles and weights to the rough handling of outsiders; but in the keenness of the interest taken by both Mr. Davis and Mr. Smith this was quite forgotten for the moment. About 180 miners turned up at the second lecture. On the third day from 70 to 90 of the miners were engaged in relays all the afternoon assaying with Mr. Fenton, many of them taking an active part in all the processes except the weighing of the fine metals in which they could not participate owing to the small size of the balance room. In the evening at 7 o'clock we found about 220 men assembled for the testing class and lecture, and the furnace room was far too small to accommodate them in the usual way. Steps were immediately taken however to plank the rafters, and in this way 70 or 80 men had accommodation overhead, and there they remained in perfect silence looking down on the proceedings at the testing table for four hours. At this meeting Mr. McLaren, inspector of mines, presided, and by his geniality and enthusiasm and knowledge of the men did good service in explaining from the chair the object of the classes and urging all to avail themselves of the facilities for technical instruction in their own industry now placed at their disposal. The meeting here was opened about 7 p.m. and it was after midnight when it broke up. It was indeed without exception the most enthusiastic meeting I have ever had on the gold fields. Most of the men had come with paper and pencil, and those who were not themselves taking part in the processes were taking, as well as they could, notes of the proceedings. I was never so impressed as I was that night at Karangahake with the intelligence, perseverance and energy which the miners can bring to bear on any subject in which they are intensely interested. Here we had many of them analysing and assaying silver ores with quite sufficient accuracy by the useful laboratory and furnace process, while three days before very few of them could identify silver ore when they saw it, much less could they form any idea of the proportion of silver which it contained.

Large attendance at lectures and assaying classes.

It would be one of the chief functions of a colonial school of mines to investigate the character and composition of our gold and silver bearing stone and other valuable minerals, to procure and disseminate among those concerned the most recent information about their treatment elsewhere, and to guide the miner in the application of sound and scientific principles in their development and metallurgy. There will thus be saved to the colony the useless expenditure of much money and a great deal of energy in hopeless directions, and the country will be in a position to profit by whatever mineral wealth our mountains contain.

Functions of a school of mines.

GOVERNMENT ASSISTANCE TO SCHOOLS OF MINES.

The mines department has imported from London for the use of the schools chemicals and apparatus to the value of about £400. It has also procured from Germany eleven collections of ores, rocks and other minerals for distribution among the schools of mines. Each of these collections cost about £35 and includes 200 specimens of metallic ores, 50 specimens of rocks and 30 specimens of minerals that accompany the metallic ores and are indicative of the same, besides an assortment of minerals to show degree of hardness and 110 samples for blowpipe testing, with blowpipes for the same.*

Appliances for schools.

THE MINISTER'S REPORT ON THE SCHOOLS.

With regard to the important and useful work being carried on in connection with the schools of mines at the many mining centres throughout the colony where they have been established, it seems to me that one of the first and surest steps towards developing the mineral resources of New Zealand is to give every opportunity and encouragement to our mining

Practical character of the instruction.

* The Handbook of New Zealand Mines, Appendix, pp. 1-13.

population to become thoroughly well acquainted with the various ores that exist in different parts of the colony, in order that miners who cannot detect the nature of any ore by sight may be able to test it by analysis and ascertain its value. It is only by such means that we may look forward to our mineral lodes being properly prospected and intelligently worked, and the combination of metals in refractory ores being more easily discovered and understood, for hitherto this last description of ore has considerably puzzled the most scientific and practical men among the mining communities. Schools of mines have been established in all the chief mining centres, and they may fairly be termed excellent schools for technical education. It is really astonishing to learn of the good work done in the direction of teaching not only the adult miner but the youthful student as well, and so eager are all classes that attend these schools to acquire knowledge and information on subjects connected with minerals and their analysis that they have formed themselves into local bodies in the several centres and have subscribed handsomely towards funds for the erection of buildings and had the same fitted up with convenient laboratories, with assaying furnaces capable of testing the component parts of any ore or other mineral that may be met with. Much of the success of these schools is due to the energetic and enthusiastic manner in which Professor Black of the Otago university first inaugurated them, and then carried on the courses of lectures with unflagging zeal throughout the whole mining districts of the colony. Last year Professor Black confined his teachings to the Middle island, with his assistants; and Professor Brown of the university college, Auckland, in conjunction with Mr. Montgomery of the Thames school of mines, undertook the supervision and instruction of the schools in the North island. The great interest with which Professor Brown has taken up this work and the anxiety he has shown to try and improve the knowledge of the mining communities among which he travels may be gleaned from the interesting and instructive lecture he recently delivered in Auckland on the subject of the extraction of gold and silver from the ores in the Thames district. Through the good offices of the late Sir Julius von Haast I was enabled to obtain last year from Germany fifteen sets of mineral specimens complete, and twelve of these have been distributed among the principal schools of mines. One set will be kept in Wellington for reference and comparison and two remain to be handed over to other schools that are still without. These specimen sets have been found to be most useful to the miners and students generally attending the schools, as they have been so well and carefully selected and marked that each specimen can with ease be compared with any other natural specimen found in the country and its nature immediately detected. Up to the present time there have been established 24 schools of mines throughout the colony; five of these are in the North island and the remainder in the Middle island, full details of which, with an account of their state of efficiency, will be found in the several reports furnished by Professor Black and his assistants. The total cost of imparting instruction and information and subsidies given to the schools up to the end of March last was £4,193, and the expenditure for same during last year was £2,924. I feel great satisfaction in reporting such good results from the formation of these schools and the great interest shown by the mining communities in them; and I consider that the colony is indebted to Professor Black and Professor Brown and their assistants for the energy and enthusiasm displayed in conducting the necessary instruction in the manner they have hitherto done. The course of instruction given has already proved itself of incalculable benefit to the miners and other students, and I believe ultimately will be the means of establishing a better system of working the mineral lodes, and in saving a very large percentage of metals that otherwise would be allowed to go to waste.*

Sets of mineral specimens.

Cost of maintenance.

* From the report of the Minister of Mines, 1887, p. 15.

REPORT OF THE SECRETARY OF MINES.

As already mentioned, the miner is confronted with the problem of how to treat the ores in which gold, silver, and other metals occur in combination. One important step towards its elucidation has already been made in teaching him how to recognise the constituent metals in the ores. Dr. Black, professor of chemistry and metallurgy at the Otago university, during each of the summer vacations of the last three years visited the principal mining districts, delivering lectures on chemistry and teaching miners the tests to apply in the detection of the various metals. The results have been well worthy of this labor, for the miners from their calling being of a very observant nature have profited greatly by the scientific instruction. It has literally been a case of the seed falling on good ground and producing fruit many fold. It is largely due to Dr. Black's labors and to the attempts at smelting by the Lamonte process that the miners of the Thames realised as they now do the presence of the silver and other metals that were being shot out on the heap of tailings like so much rubbish. A great incentive has been given to prospect new fields, for in the simple tests the miner has learned to apply he is armed with a talisman to unlock the secrets of nature. It is true that it is one thing to know what is in an ore and quite another to dissociate the metals composing it, on the large scale. But we are on the right track of discovery in having awakened the spirit of enquiry among so many intelligent men who are supplied at various points with the means of pursuing their inquiries in the laboratory. On account of the expense it is of course impossible to equip and maintain laboratories on all the gold fields. But, recognising the importance of keeping this spirit of inquiry alive, well equipped laboratories are maintained both at the Thames and at Reefton—the two principal quartz-mining districts—in charge at each place of an officer trained under Dr. Black. At the Thames Mr. Montgomery has charge, and Mr. Fenton at Reefton.. Their duties are to make analyses and teach the miners, old and young, in the chemistry of their work. It is reasonable to hope that the outcome of so much intelligent application will be the discovery of a method of treating the ores so as to make the most refractory of them yield up their wealth. The expenditure on schools of mines since their inauguration has been as follows :

Practical benefits of the instruction.

Laboratories

Expenditure.

	£	s.	d.
Subsidies towards the erection of buildings..........	511	12	3
Chemicals and mineralogical specimens...............	699	15	2
Salaries of teachers and travelling expenses..........	5,654	8	7
Total....................................	£6,865	16	0

In addition to this the liabilities amounted at the end of March last to £337 4s. 3d., exclusive of £600 which was authorised as subsidy towards the erection of a testing-plant in connection with the Thames school of mines †

VICTORIA SCHOOL OF MINES.

Dr. R. W. Dale in his impressions of Australia says: "Victoria has a school of mines at Ballarat and another at Sandhurst; it is supposed to be a great advantage to the students that they can go down into the mines, which are within half a mile of their lecture rooms and laboratories, and examine for themselves the methods of working them and the manner in which engineering difficulties have been met and mastered. The Ballarat school of mines is not yet affiliated to the university, although it prepares students in mining among other subjects. It gives "certificates of competence" in assaying, including metallurgy. It has a well equipped laboratory with six lecturers and professors of mining subjects, and prepares students for university degree examinations.

Victoria school of mines, Australia.

* From the report of the Secretary of the Department of Mines, 1888, p. 5.

M.—MUSEUM OF ECONOMIC GEOLOGY.

UTILITY OF A COLLECTION OF MINERALS.

Sir William Logan's conception of a geological museum.

The act making provision for a geological survey of the province contemplates as one of its objects the establishment of a provincial museum for the purpose of illustrating by maps, specimens and descriptions the geological structure of the country, and of affording a view of its mineral resources; and the government having placed at the disposal of the Survey a building in which the arrangement of the materials that have up to this time been brought together can be commenced, it may be proper to draw your Excellency's attention to the subject. Of the utility of such a museum for the purposes of instruction, if the arrangement of its detail is properly carried out, there can be no doubt; and one branch of the subject which, it appears to me, should be specially attended to is that which relates to economic geology. In museums connected with educational institutions minerals are usually exhibited as they are related to one another in chemical composition, in crystalline form, or other outward mark by which they are distinguished; such collections are useful to enable a learner to acquire a general knowledge of mineralogy. Or they may be arranged in their geological relations, showing how the minerals are grouped in the veins or beds which contain them, what species of rocks the veins cut, and the attitude of both the veins and the strata; and if to this be added the order of sequence in the strata, as they are marked by their fossils, the collection would teach geology, including the art of discovering useful minerals. But another arrangement of which mineral substances are capable, and which is not found in ordinary educational institutions, regards their application to the purposes of life; it is particularly in the exhibition of the useful minerals of the country and the illustration of their applications by examples that a collection connected with a geological survey is of essential advantage, and it is while a geological survey is in operation that such a collection can be best acquired. Including this branch of the subject, the collection of the Survey would show the mineral and mechanical character of the rocks of the province, their sequence in the order of superposition, the fossils they contain by which nature has marked them as with a brand, rendering them recognisable wherever they are met with, the attitude they have beneath the surface, their geographical distribution, and with that the geographical distribution of the useful materials they hold, and then the purposes to which these materials can be applied. To illustrate these uses properly would necessarily require a good deal of the manipulation of the artisan. It would be necessary to saw and polish blocks of marble and other stones, to dress and prepare slates, to dress building materials,—in short to give to each substance the various useful forms which it is capable of receiving. . . . In a new country just beginning to ascertain its possesion of useful minerals, one of the most difficult things possible is to introduce the skill requisite to make them available.

Methods of arranging specimens.

A school of mineral arts

Descriptions of them and their applications may be printed and published, but it is not easy to get the descriptions read; indeed a vast number of those whose labor might be available to turn the materials to profit can read with difficulty or not at all; but it requires little tuition to comprehend the objects of industrial art when addressed to the eye, and imitative skill is more excited by the sight of such objects than by written descriptions even when understood. In a collection of them many persons to whom the knowledge would in no otherwise come may recognise substances which they have in abundance at their own doors, but of which they know not the use. The examples which show their uses may prompt attempts to make them available, and the collection thus becoming a school of mineral arts would be a means of exciting native industry.*

* Sir William Logan in the Geological Survey report, 1851-2, pp. 54-6.

THE MUSEUM AS AN ADJUNCT OF THE TECHNICAL SCHOOL.

The museum, to those not well acquainted with its uses and with the derivation of the word, is associated with amusement, but the *amŏusŏi* were the uncultivated and the unlettered who went to the museums, the places devoted to literature and the fine arts, with more or less of a hope of instruction as well as amusement. The museum itself was dedicated to the muses and maintained by the lovers of art, and to such a place, well arranged by the thoughtful teacher, the earnest student should be encouraged to go for aid in the study of his science, for recreation when overburdened, and for as sure a way of reaching his end as by oral instruction or book-learning, while the mere curiosity-seeker will be sure to carry away with him from the museum, if no other idea, that of order and classification. The museum is the necessary adjunct to the technical school, because it helps to familiarise the eye with colors, forms, associations and proportions of things with which the student must in any case become familiar. Passing by and seeing, even without study, a mineral, a chemical, a part of a machine or its whole, will familiarise him with color, shape and proportion in a short time without effort, as much as many hours of study, and more than the memorising of a complete description from a book. Nor is it enough that the student should see only. He should be able to handle, to look over and to examine samples and specimens, placing them in every position so as to become familiar with all their conditions, their weights, their dimensions, their proportions. No amount of book knowledge would make it possible to distinguish minerals which are very much alike, or even if it did, could only be acquired at the expense of an unwarranted amount of time, not in any way proportioned to the value of the knowledge acquired. Museums in a technical school should be arranged on a principle which will bring out the relations of the things they are intended to illustrate. I am strongly an advocate of making all such museums, where it is possible, passageways through which students must walk to and fro in going to and coming from their various class-rooms, and of placing on the walls of the class and lecture rooms collections where the eye may rest, even though it be for only an instant, in the intervals during the interruptions of thought. The eye in this way becomes unconsciously familiarised with objects which from their previous familiarity with them, when they commence to study them closely, do not strike the terror into the heart which an absolutely new and unfamiliar thing sometimes does, thus making the subject less difficult. The order, the arrangement and the classification of the objects exposed carry with them a most useful lesson, which is unconsciously absorbed and teaches systematic methods better than almost any other way in which they could be taught. The museum thus becomes a powerful object-teacher. Its instruction is all the more emphatic because silent, and the principles or facts which are demonstrated in the arrangement all the more impressive because they are unconsciously learned. The student is thus without effort made to think that this or that must of course be true—we have always known it. It thus makes the acquirement of certain kinds of principles easy, where they might otherwise have been difficult if this powerful object-teacher, the museum, had not been brought into play. Familiarising the eye of the student with good types makes knowledge of what is proportion almost intuitive. Beauty then becomes an element in his future design, to which his analytical knowledge will never allow him to sacrifice strength or utility. If the eye has been properly trained the drawing of a section stands out to him in relief, and he can distinguish by means of it what is behind or on one side as well as what is shown in the section or side of the relief which the drawing exhibits. There is always the danger in teaching from models, even though made to a scale, unless the idea of relative dimensions has been taught, that the real thing in its own proper scale will appear heavy and clumsy, and thus generate the habit of making things too light. This can

The museum a necessary adjunct of the technical school.

How arranged and placed.

The museum an object-teacher.

always be guarded against by having the sections of parts of full size where they can be seen and handled. In my opinion too little is made of museum education in this country and too little floor space given to museums. They should be open throughout the entire day and be contained in well lighted and well ventilated rooms. The students should have free excess to them at all times, and should be encouraged to pass as much time in them as is consistent with duties in other directions.*

The ideal museum.

N.—MINERAL PRODUCTION OF 1888.

The table on next page gives, by quantities and values, the mineral products of Canada and the United States for the year 1888. It does not include the articles of brick, charcoal, coke, fertilisers, glass and glassware, iron, iron ore, pottery ware, sewer pipe and tile, steel, sulphuric acid, terra cotta and tile in the Canadian table of production, as these are properly manufactures. In commenting on the total value of the minerals produced in the United States in 1888 the report says: "It is recognised that this is the sum of the values of substances taken in various stages of manufacture, and hence not strictly comparable with each other; still it is the most valuable means for comparing the total products of different years. The result is an increase of over $40,000,000 beyond the value of the product in 1887. In that year nearly every mineral industry showed an increase, and hence an increased total was evident. But the fact that the increase was so very large was due to rather exceptional conditions in a few important industries, and it could not reasonably be expected that a similar combination of circumstances would result in even a larger total value for 1888. Nevertheless the unprecedented stimulus given to the production of copper by an artificial price increased the total value of that product nearly $13,000,000, or nearly enough to offset the decline in the total value of pig iron. The other important factors in the increase were coal and the other fuels which followed the increased quantity of metals. With the anticipated decline of copper to the normal demand, a decline in the total value of the product in 1889 will not be inconsistent with the natural development of our mineral resources."

The increase of United States products.

* Prof. Egleston, in the Transactions of the American Institute of Mining Engineers, vol. XVI, pp. 647-9.

MINERAL PRODUCTS OF CANADA AND THE UNITED STATES IN 1888.

Products.	United States.		Canada.	
	Quantity.	Value.	Quantity.	Value.
Metallic products—				
Pig iron....................tons...	6,489,738*	$107,000,000	21,799	$313,235
Silver ....troy oz	45,783,632	59,195,000		395,377
Copper ....pounds	231,270,622	33,833,954	5,562,864	667,543
Gold ....troy oz	1,604,927	33,175,000	61,310	1,098,610
Lead, value ....tons...	180,555	15,924,951	337	27,472
Zinc.................... do ...	55,903	5,500,855		
Quicksilver ....flasks..	33,250	1,413,125		
Nickel....................pounds	203,328	127,632		
Aluminium.................... do	19,000	65,000		
Antimony ....tons...	100	20,000	345	3,696
Platinum ....troy oz	500	2,000	1,500	6,000
Non-metallic mineral products—				
Bituminous coal ....tons...	91,106,998*	122,498,141	2,658,134	5,259,832
Pennsylvania anthracite .... do ...	41,624,611*	89,020,483		
Building stone....................		25,500,000		641,712
Lime ....barrels	49,087,000	24,543,500	2,216,764†	339,951
Natural gas		22,629,875		
Petroleum ....barrels	27,615,929	17,950,353	733,564	755,571
Cement .... do	6,253,295	4,533,639	50,668	35,593
Salt .... do	8,055,881	4,374,203	59,070‡	185,460
Limestone for iron flux.........tons...	5,438,000*	2,719,000	16,857	16,533
Phosphate .... do ...	448,567	2,018,552	22,485	242,285
Mineral waters....................gallons	9,628,568	1,709,302	124,850	11,456
Zinc-white ....tons...	20,000	1,600,000		
Gypsum .... do ...	110,000	550,000	175,887	179,393
Borax ....pounds	7,589,000	455,340		
Mineral paints....................tons. .	24,000*	380,000	397	7,900
Asphaltum .... do ...	53,800	331,500		
Manganese ore.................... do ...	29,198*	279,571	1,801	47,944
Flint .... do ...	30,000*	175,000		
Pyrites .... do ...	54,331*	167,658	63,479	285,656
New Jersey marls.................... do ...	300,000	150,000		
Crude barytes .... do ...	20,000*	110,000	1,100	3,850
Bromine ....pounds	307,386	95,290		
Corundum....................tons...	589	91,620		
Gold-quartz, souvenirs, jewelry, etc....		75,000		
Mica ....pounds	48,000	70,000	29,025	30,207
Precious stones		64,850		
Felspar ....tons...	8,700*	50,000		
Graphite ....pounds	400,000	33,000	300,000	1,200
Fluorspar ....tons...	6,000	30,000		
Slate ground as pigment ...... do ...	2,500*	25,000		
Chrome iron ore .... do ...	1,500*	22,500		
Novaculite ....pounds	1,500,000	18,000		
Cobalt oxide .... do	8,491	15,782		
Rutile .... do	1,000	3,000		
Asbestos ....tons...	100	3,000	4,404	255,007
Other articles..				338,566
Resume of values—				
Metals		256,257,517		2,511,933
Mineral substances named in the foregoing table....................		322,293,159		8,638,116
Estimated value of mineral products unspecified		6,000,000		898,372
Grand total		$584,550,676		$12,048,421

* Long tons; in all other cases the measure is short tons. † Barrels. ‡ Tons.

GLOSSARY.

GLOSSARY OF GEOLOGICAL AND MINING TERMS.

Accessory Minerals—Minerals found in crystalline rocks in such small proportions that their absence would not alter the lithological name of the rock.

Acid Rock—A rock containing much silicic acid (free silica), as opposed to basic rock in which the alkaline bases predominate

Adit—A horizontal tunnel or gallery driven from the open air on the side of a slope or bluff into a mine.

Aerolites—Meteoric masses of metallic or other mineral substances which have fallen to the earth through the air. The metallic aerolites consist principally of metallic iron, nickel and chrome, and the non-metallic of crystalline rocks resembling greenstones ; others consist of mixtures of these.

Agglomerate—An accumulation of more or less rounded fragments of rock in an old volcanic vent or immediately connected with a volcano, the rounding having been due to friction in the volcano and not to the action of water as in the case of conglomerate.

Albite—Soda felspar; a silicate of alumina and soda. Crystallisation, triclinic.

Alluvium—Recent aqueous deposits of silt or mud.

Alumina—Oxide of aluminium. Pure crystalline alumina is represented by corundum, sapphire and ruby. The commonest form of alumina is as a silicate, of which clays are mostly composed, and as the compound silicates of aluminium and other metals, of which a very large class of minerals is formed.

Amalgam—A combination of mercury with another metal, especially gold or silver.

Amalgamation—The process of uniting mercury with gold, silver, etc.

Amorphous—Without form ; applied to rocks and minerals having no definite structure.

Amphibolite—See *Hornblende.*

Amygdaloid—An igneous rock containing almond-shaped kernels of minerals such as quartz or agate, calcspar, etc., which have resulted from the filling up of vesicular cavities that originally existed in these rocks, due to the expansion of gases in them while still hot and in a soft condition.

Anorthite—Lime-felspar ; a silicate of alumina and lime; crystallisation, triclinic.

Anthracite—Or hard coal ; a variety of coal from which nearly all the bitumen has been driven off by a process of natural coking, leaving the fixed carbon and the ash.

Apatite—Mineral phosphate of lime. It is usually of various shades of green and bluish green, brownish red and light gray. It occurs in grains and small crystals in nearly all trappean rocks, in granites, gneiss, etc. In the Ottawa valley and the region between Kingston and Ottawa it occurs in economic quantities, associated with pyroxene rock and crystalline limestone. The first grade for export has the refuse rock removed so that the mass contains 80 per cent. and upwards of pure phosphate. Apatite represents the fifth degree in the scale of hardness of minerals.

Aqueous Rocks—See *Sedimentary.*

Arastra—A primitive contrivance for the reduction and amalgamation of gold or silver in ores. It consists of a shallow tub-shaped enclosure usually about twelve feet in diameter formed of either iron or stone. An upright shaft fixed to pivots above and below stands in the centre, and from it arms extend, to which horses or mules are attached. Blocks of stone attached by thongs or chains to these arms are dragged around upon the stone pavement or iron plate which forms the bottom, in such a way that the front of the lower surface of each block is slightly raised so that it may pass over the finely broken ore and triturate it upon the bottom. After grinding the ore to a pulp, sufficient mercury is added to amalgamate all the precious metal supposed to be present and the grinding process is continued for some time.

Archæan—A term proposed by Dana and largely adopted for the Azoic Period or Age, or what had formerly been called the primitive rocks, the lowest of the five grand divisions or periods of geological time. They embrace the Laurentian and Huronian systems and are sometimes also called the Pre-Cambrian rocks. See *Azoic*, *Laurentian* and *Huronian*.

Arenaceous—Sandy ; rocks composed of sand or containing sand along with other ingredients, as arenaceous limestone.

Argentiferous—Carrying silver ; silver-bearing.

Argentite—Sulphide of silver; contains $86\frac{1}{2}$ per cent. of silver and $13\frac{1}{2}$ of sulphur ; heavy blackish-gray in color, malleable, easily cut by a knife ; it is an important ore of silver, common in the Thunder Bay silver region.

Argillaceous—Containing clay, either soft or hardened, as in shale, slate, argillite, etc.

Artesian Wells—Deep wells bored through the solid strata. In properly selected situations the water generally rises in them to the surface, or flows over.

Asbestos—A fibrous, flexible variety of hornblende. Chrysotile, a fibrous variety of serpentine, is also called asbestos. It fuses at a lower temperature, but for steam-packing answers the same purpose as true asbestos.

Assaying—Finding or determining the proportion of metals in ores by smelting in the way appropriate to each. Gold and silver require an additional process called cupelling, for the purpose of separating them from the base metals.

Attitude—Position, aspect, dip, conformation, structure.
Auriferous—Carrying gold; gold-bearing.
Azoic—Without life. Applied to all the ancient crystalline rocks, because they show no evidence of the existence of life on the earth at the time of their formation.
Back—A joint or dry fissure from which the rock in front may be separated. The ground in a mine between a level, drift or adit and the surface.
Barytes—Sulphate of barium; also called heavyspar, from its high specific gravity. When finely ground it is used as a substitute for white lead paint. It occurs as a veinstone and is abundant in some of the veins between Thunder bay and Pigeon point.
Basalt—Igneous rock having a columnar structure like that of the Giant's causeway in Ireland. Lithologically, basalt is closely allied to diabase.
Basin—In geology, where strata dip from all sides towards a central point or line; also called a synclinal or trough as opposed to anticlinal or dome, where the rocks dip away from a common line or point.
Basic Rock—A rock in which the alkaline bases predominate over the free silica.
Battery—A set of stamp-heads working in the same mortar box.
Bed—A layer or stratum of rock of a uniform character. It may be separated by mere lines of bedding or partings from others like it, or it may be associated with beds which differ from it in color, texture, composition, etc.
Bedding—See *Stratification.*
Bed-rock—The solid rock underlying auriferous gravel, sand, clay, etc., and upon which the alluvial gold rests.
Belt—A term used in the description of the geographical distribution of strata, especially if inclined strata, to indicate a zone or band of a particular kind as exposed on the surface.
Bitumen—Mineral pitch; it is composed of carbon and hydrogen.
Bituminous—Containing disseminated bitumen or its elements, which may generally be distinguished by the dark color or the odor.
Bituminiferous—Carrying free bitumen.
Bitterspar—Also called Pearlspar. The crystalline form of carbonate of lime and magnesia; the pure form of dolomite. It consists of one part or equivalent of carbonate of lime and one of carbonate of magnesia.
Black-Jack—Dark varieties of zincblende or sulphide of zinc. It has a resinous lustre and yields a light colored streak or powder.
Black-Lead—The vulgar name for graphite, because it gives a mark on wood or paper like that of metallic lead. Graphite is also called plumbago from the same circumstance.
Black Sand—Heavy particles consisting of black oxides of iron which accompany alluvial gold.
Blende—Without any qualification means zincblende or the sulphide of zinc, which has the lustre and often the color of common resin, and yields a white streak and powder. The darker varieties are called black-jack by the English miners. Other minerals having this lustre are also called blendes, as antimony-blende, ruby-blende, pitchblende, hornblende.
Blood-stone—A dark green variety of chert or jasper with small red spots.
Bog Iron Ore—A spongy variety of hydrated oxide of iron or limonite. Found in layers and lumps on level sandy soils which have been covered with swamp or bog.
Boulder—A loose mass of rock, usually more or less rounded, and larger than a pebble or a cobblestone, or say more than a foot in diameter.
Boulder-Clay—The stiff, hard and usually unstratified clay of the drift or glacial period, which contains boulders scattered through it; also called till, hardpan, drift-clay, or simply drift.
Brace—The platform, collar or landing at the mouth of a shaft.
Breccia—A rock formed of angular fragments, whereas in a conglomerate the fragments are rounded.
Brown Coal—A name given to lignite. (See *Coal*).
Buddle—A circular tub, pit or enclosure for separating finely divided ores from the waste by means of water. The surface of the accumulated ore in the buddle is either convex or concave, according as it is fed from the centre or periphery, and is raked by revolving brushes.
Buhr-Stone—A spongy silicious rock used for millstones. The kinds most in use come from Tertiary strata in France.
Bunch—In mining, an irregular mass of ore of considerable size.
Caen-Stone—A fine-grained cream-colored magnesian limestone from Caen in Normandy. It is so soft when freshly quarried that it may be cut by a saw, but hardens on exposure. Much esteemed as a building stone.
Cage—A frame in which tram-cars are lowered and raised in mine shafts.
Cainozoic—See *Tertiary.*
Calamine—The natural carbonate of zinc; one of its most easily reduced ores; occurs both in beds and veins, mostly in the Carboniferous and higher rocks.
Calcareous—Containing carbonate of lime, as calcareous sandstone, or composed of it, as calcareous spar or calcspar.
Calcareous-Tufa—A spongy, porous or vesicular deposit of carbonate of lime from water. It often incrusts vegetable and animal substances, which are thus said to be petrified. When the carbonate of lime is deposited in a more solid form it is called travertine or calc-sinter. Stalactites and stalagmites are of this nature.
Calcedony—See *Chalcedony.*
Calciferous—Carrying carbonate of lime.
Calc-Spar—See *Calcareous.*

Calcining—Burning or roasting ores or other minerals as part of their treatment for smelting, crushing or otherwise utilising them.

Cam—A projection from a revolving horizontal shaft for raising the stamp by catching the lower surface of the tappit or collar surrounding the rod on which the stamp-head is hung. The upper side of the cam has an easy curve, such as a parabola, so that when it strikes the tappit it may not jar it when the lifting movement begins.

Cam-shaft—A strong horizontal revolving shaft to which a number of cams are attached in such a manner that no two of them may strike the tappits at the same instant, thus distributing the weight to be lifted.

Cambrian—Derived from Cambria, the ancient name of Wales. The name given by the late Professor Sedgwick of the University of Cambridge to the most ancient system of fossiliferous rocks.

Canon—A ravine or gorge, generally on a large scale.

Cap, Cap-rock—An unscientific term used to indicate the country rock by which a vein is pinched at the surface.

Carbonaceous—Coaly, or containing coaly matter.

Carboniferous—Coal-bearing.

Carboniferous System—The system of rocks which succeeds the Devonian or "Old Red Sandstone," and precedes the Permian or "New Red Sandstone." It is characterised by its containing workable seams of true coal.

Carnelian—One of the varieties of chalcedony—originally only the red, but now of any color.

Casing—The lining of a shaft, the tubing of a well; also applied to the decomposed matter sometimes found between a vein and the wall-rock.

Cavernous—Containing cavities or caverns, sometimes quite large. Most frequent in limestones and dolomites.

Celestine—Sulphate of strontium—a mineral which resembles barytes in its high specific gravity and is often mistaken for it. It may be used for many of the same purposes in the arts.

Cement—The calcareous, silicious, ferruginous, etc., matter, cementing together gravel, broken fragments of rock, etc.

Cerussite—Natural carbonate of lead, which sometimes occurs in economic quantities.

Chalcedony—Translucent varieties of quartz, such as carnelian, agate, silicious sinter, etc.

Chalk—Originally and properly the soft amorphous variety of limestone of the cretaceous system used for marking, but now also applied to other substances, as red chalk or clayey oxide of iron, French chalk or steatite or soapstone.

Chalybeate—Irony; waters containing iron, usually the carbonate of iron in solution, are called chalybeate.

Chert—A brittle nearly opaque variety of flint. It generally occurs as nodules or thin irregular beds in limestones.

Chlorite—A soft, dark green mineral, entering largely into the composition of chloritic schist. It is a silicate of alumina, magnesia and iron, and has a peculiar earthy odor when freshly broken and breathed upon.

Cinnabar—Sulphide of mercury. A very heavy, red, granular crystalline mineral, giving a bright red streak and easily reduced to metallic mercury.

Claim—Any area of mining ground staked off or held in accordance with the regulations of the district in which it is situated.

Clastic—Broken, fragmental; a rock composed of pieces, or of fine grains which have been formed by the breaking down of pre-existing rocks, as opposed to crystalline and other rocks which have been formed from the cooling of molten matter or from the alteration of sedimentary rocks to such an extent as to obliterate all traces of an original fragmentary origin.

Clay-Ironstone—Clayey carbonate of iron. A heavy compact or fine grained clayey looking stone, occurring in nodules and uneven beds among carboniferous and other rocks. It contains only 20 to 30 per cent. of metal, and yet much of the iron produced by Great Britain is made from it.

Cleaning-up—The process of collecting together the metal or ore which has accumulated in the various contrivances for saving it by mining machinery.

Cleavage—The property possessed by slates and schists of splitting in one direction, which may or may not correspond with the bedding. It is believed to have been produced by great pressure acting at right angles to the cleavage-planes, which has had the effect of forcing the longer diameters of all the particles into parallel positions corresponding with the cleavage. When the cleavage-planes are quite parallel the rock is called a slate, but when only approximately so and the rock breaks into irregularly lenticular and wedge-shaped pieces it is a schist. A schistose structure is believed to have been developed by pressure and shearing in certain crystalline rocks, such as diorite, which might have otherwise remained massive or homogeneous.

Coal—Mineralised vegetable matter. The vegetable matter appears to have first taken the form of peat, then lignite, and finally bituminous coal. The latter by the loss of its bitumen has in same places been converted into anthracite or hard coal. Lignite gives a brown powder, coal a black. Lignites contain a considerable percentage of water; bituminous coal only 5 per cent. and less. Bituminous coals will coke, lignites will not. Coals and lignites contain the ashes of the plants from which they have been formed, and also mineral matter brought by water before they became consolidated.

Cobble-Stones—Smooth flattened, rounded or elongated stones, larger than pebbles and smaller than boulders. They form durable street pavements by being set on edge close together.

Coke—When the bitumen is driven out of coal by heating it out of contact with air, as in ovens constructed for the purpose, the residue is called coke.
Color—Minute particles of gold obtained by panning and too small for their value to be estimated.
Columnar—Resembling columns. The cliffs of trappean rocks or diabases of Thunder cape, lake Nipigon and the country north of Black bay have a columnar structure.
Compact—A rock is said to be compact when the grains are too fine to be visible; jasper and lithographic stone are examples.
Complex—In mineralogy, containing many ingrediénts, compound or composite. Some United States geologists use the word as a noun to indicate a complex set of rocks folded together, or intricately mixed, involved, complicated or enlarged.
Conchoidal—Shell-shaped. The more compact rocks such as flint, argillate, felsite, etc., break with concave and convex surfaces and are therefore said to have a conchoidal fracture.
Concretionary—Tending to grow together. Particles of like chemical composition, when free to move, come together and form nodules of various sizes and shapes which are called concretions. Clay and ironstone nodules, balls of iron pyrites, turtle-stones, etc., are good examples. Some greenstones exhibit concretionary structure.
Conformable—When beds or strata lie upon one another in unbroken and parallel order they are said to be conformable, and this arrangement shows that no disturbance or denudation has taken place at the locality while their deposition was going on. But f one set of beds rests upon the eroded or the upturned edges of another, showing a change of conditions or a break between the formations of the two sets of rocks, they are said to be unconformable.
Conglomerate—A rock formed largely of rounded pebbles and stones, held together by a matrix or paste of any composition.
Contemporaneous—Existing together or at the same time.
Contorted—Bent or twisted together. Used where strata are very much folded or crumpled on a considerable scale. If on a small scale they are said to be corrugated.
Contact Vein—See *Vein*.
Contraction—Shrinking. Rocks in passing from a vitreous to a crystalline texture shrink considerably, which may account for the subsidence of certain areas. The whole globe of the earth has shrunk by cooling. This contraction is a cause of volcanic action.
Coprolite—A piece of petrified dung.
Corrugated—When beds on a small scale are much wrinkled, folded or crumpled, they are said to be corrugated. On a larger scale they are said to be contorted.
Country, Country Rock—The general rock-mass in which mineral veins or deposits are held.
Cradle—A wooden box, longer than wide, provided with a movable slide and hopper, and mounted on two rockers. It is used for washing gold-bearing earths.
Crater—The cup-shaped orifice of a volcano.
Creek—In Canada brooks are often called creeks.
Creep—In mining, the gradual relative movements of rocks owing to the removal of support by excavations.
Cretaceous System—The system of rocks next above the Permian, so called from the abundance of chalk which it contains in England. In America the same system as recognised by its fossils holds but little chalk.
Crop or *Outcrop*—The coming to the surface or exposure o a rock.
Cross-Course—A vein crossing the general course of a more important one.
Cross-Cut—A drift or level, driven across the course of a vein or tilted bed, generally for the purpose of intersecting it or of ascertaining its width or richness.
Crushing—Reducing ores or quartz by stamping or passing through rolls.
Crushing-Mill—The same as stamp mill (which see).
Cryolite—A soft white translucent mineral which melts in ordinary flame. It consists of fluoride of sodium and aluminium, and is valuable for the manufacture of carbonate of soda and of metallic aluminium. It occurs in veins in gneiss in West Greenland, and may be looked for among the gneisses of Canada.
Crystals—The various geometric forms assumed by nearly all the solid chemical elements and definite compounds, whether natural or formed artifically. The countless modifications of crystalline forms are all grouped under six systems.
Crystalline Rocks—Consisting of crystalline particles or grains; when the latter are distinct the rock is said to be crystalline-granular.
Crystallography—The description cr science of crystals.
Cupriferous—Copper-bearing.
Damp—Miners in England call gases "damps"; carbonic acid gas is choke-damp, and light carburetted hydrogen is fire-damp.
Dead Ground—Rock in a mine which, although producing no ore, requires to be removed in order to get at productive ground.
Decomposition—The breaking up or decay of compounds into simpler chemical forms.
Decrepitation—The breaking up with a crackling noise of mineral substances when exposed to heat, as when common salt is thrown upon the fire.
Delta—The alluvial islands at the mouth of a river, which generally have a triangular form like that of the Greek letter delta.
Denudation—The washing down of surface deposits so as to lay bare underlying formations. This washing away in one place is associated with the idea of deposition in another.
Deposit—Anything laid down. Formerly applied to matter left by the agency of water, but now made to include also mineral matter in any form, and precipitated by chemical or other agencies, as the ores, etc., in veins

Detritus—Accumulations derived from the wearing down of rock surfaces.

Devitrification—The change from a glassy to a crystalline state.

Devonian System—The geological system of rocks above the Silurian and below the Carboniferous; so called from Devonshire. In Scotland it was called the Old Red Sandstone.

Diabase—A dark green, greyish green or nearly black igneous rock, one of the "greenstones," consisting of a triclinic felspar, augite (or pyroxene) and usually some olivine, with magnetic or titaniferous iron, apatite and iridite as accessory minerals. It occurs as dykes, beds, overflows and irrupted sheets and masses, and it may be coarsely or very finely crystalline. It is common in all the above forms around lake Superior and north of lake Huron. Diabase differs from basalt in having undergone certain interval mineralogical changes, without however affecting its general chemical composition, which is the same in both. Some varieties of amygdaloid have the composition of diabase.

Diagonal Stratification—Also called false bedding and current bedding. Many sands and sandstones are marked by lines of subordinate stratification running through the main beds at various angles to their planes; these are due to currents at the time of deposition, and they have received the above names.

Diallage—A very cleavable variety of augite or pyroxene. Gabbro or Diallage-rock is composed of this mineral and a triclinic felspar.

Diluvium—Accumulations of gravel, etc., supposed to be the result of the extraordinary or violent action or "washing asunder" of water as opposed to alluvium, the deposits resulting from the gentler operations of water.

Diorite—A crystalline igneous rock, outwardly resembling diabase, and also called "greenstone," but being composed of a triclinic felspar and hornblende, generally with some magnetite and apatite as accessory minerals. Diorite occurs in the same manner as diabase, and is a common rock north of the great lakes of the St. Lawrence. It is difficult or often impossible to distinguish it from diabase without microscopic examination. There are several varieties of diorite, the principal of which are quartz-diorite, containing free quartz, mica-diorite, containing black mica often abundantly, diorite-porphyry or porphyritic diorite, in which some of the felspar or hornblende is in the form of large crystals among the smaller ones. Both diorite and diabase sometimes assume a coarsely concretionary structure.

Dip—The angle at which *beds* or strata are inclined from the horizontal, while *underlie* is the angle formed between a *vein* and a perpendicular line. The first is a geologist's term, the second a miner's.

Disintegration—The breaking asunder and crumbling away of a rock, due to the action of moisture, heat, frost, air, and the internal chemical reaction of the component parts of rocks when acted upon by these surface influences.

Dislocation—A shifting of the relative position of the rock on either side of a crack or break. It may be up, down or to one side. Equivalent to slip, slide, fault, throw, heave, upthrow, downthrow, trouble.

Disseminated—To be scattered or diffused through; to be permeated with.

Disturbance—When the rock has been bent or faulted, or in any way disturbed from its original position.

Divide, Dividing-range—The water-shed or height-of-land from which the heads of streams flow in opposite directions.

Divisional Planes—Planes which divide rocks into separate masses, large or small, in the same way as joints, fissures and backs.

Dolerite—A crystalline igneous rock having the composition of basalt and diabase, but formerly supposed to belong to newer rocks. This distinction has not been maintained. The term is now used to distinguish the coarser grained varieties of basalt in which the component minerals may be distinguished by the naked eye.

Dolomite—A rock consisting of carbonate of lime and carbonate of magnesia in the proportions of one chemical equivalent of each, also called magnesian limestone. It occurs in a great many crystalline and non-crystalline forms the same as pure limestone, and among rocks of all geological ages. When calcined it answers for most of the purposes of ordinary lime. But in the caustic form it would be unfit for putting upon land as a manure. When the carbonate of magnesia is not present in the above proportion the rock may still be called a magnesian limestone, but not a dolomite, strictly speaking.

Drift—In geology, includes all loose or superficial deposits which may be supposed to have been "driven," within the regions which have come under the influence of the glacial drift, but more properly restricted to the boulder clay or till. In mining, a level, gallery or tunnel which does not come out to the open air.

Druse—A cavity in a vein or rock lined with crystals.

Dump—A refuse pile at a mine. It consists of the gangue from which the ore has been cobbed, dead rock, etc.

Dunes—Heaps of blown sand.

Dyke—A mass of igneous or intrusive rock which has been injected in a soft state between the walls of a fissure. Dykes are sometimes very wide, and these, as well as narrower ones, often run for long distances. When the enclosing rock has weathered away they stand up like walls, for which dyke is the Scotch name.

Earth's Crust—The external part of the earth, accessible to geological investigation. The use of this term does not necessarily imply that the rest of the earth is not also solid.

Earthquake—A local trembling, shaking, undulating or sudden shock of the surface of the earth, sometimes accompanied by fissuring or by permanent change of level. Earth-

quakes are most common in volcanic regions, but often occur elsewhere, as along the junction of the Laurentian and Palæozoic rocks in the lower St. Lawrence and Ottawa valleys.

Economic Minerals—Any minerals having a commercial value.

Elvan—A Cornish term for a crystalline, granular mixture of quartz and orthoclase, constituting a variety of quartz porphyry. Elvan courses are veins of this rock which occur in the vicinity of granite in Cornwall.

Emery—Properly a variety of corundum from cape Emeri in the island of Noxos, but generally used to signify the powder of corundum, a mineral consisting of alumina alone and ranking next the diamond in hardness.

Engine Shaft—Usually the principal shaft in a mine, and the one at which the hoisting and pumping are done.

Eocene—The oldest division of the tertiary system. This name was introduced by Sir Charles Lyell, and means the dawn of the recent.

Epidote—A hard mineral, usually of a grass-green or a yellowish green color, common among gneisses, greenstones and certain schists.

Epidosite—An intimate mixture of epidote and quartz forming an exceedingly hard and tough rock.

Equivalent—Used in geology in regard to rocks of corresponding age in regions far from each other. In chemistry, that proportion of a simple element or of a compound which will unite chemically with the corresponding equivalent of some other element or compound. These proportions are always definite, no more or no less being admitted.

Erosion—The gnawing or wearing away of rocks by means of denuding agencies. The disintegrating processes already referred to soften the rocks, which are then removed by the agency of ice or water aided by gravitation, etc.

Erratic—A name often given to transported boulders.

Eruption—A violent breaking forth to the surface of pent-up matters, such as lava, volcanic ashes, stones, mud, water, etc.

Escarpment—A perpendicular cliff, especially of stratified rock.

Exfoliate—To fall off in leaves or scales, as some rocks do by weathering. In this way the concretionary structure of some kinds of greenstones is well brought out, the weathered surface showing only rounded masses with the successive spherical layers falling off.

Face—A perpendicular wall of rock; the end of a drift, etc. in a mine.

Fault—The displacement of rocks along a fissure, either up or down or to one side. See *Dislocation.*

Fauna—The animals collectively of any given age or region. The plants are similarly called its *Flora.*

Feeder—A small vein falling into or joining a larger one and often enriching it or otherwise affecting its character.

Felsite—A compact rock composed of orthoclase, felspar and silica, in microscopic grains. See *Quartz Porphyry.*

Felspars—Several allied species of minerals composed of silicates of alumina and of alkalies and lime. They crystallise in different systems. The triclinic group of felspars is called collectively plagioclase. The principal species are orthoclase, albite, labradorite, anorthite and oligoclase. In granitoid rocks the felspar grains may be detected by the shining of the faces of the cleavage planes. Those of labradorite are marked by minute parallel ridges called striæ. The felspars rank sixth in the scale of hardness, or next softer than quartz, and may be scratched with difficulty by the point of a knife.

Ferruginous—Relating to iron.

Fire-clay—Clay that will stand intense heat. It consists of silicate of alumina and is almost entirely free from alkalies or lime; found principally among carboniferous and other ancient strata.

Fissile—Capable of being split, as schist, slate and shale.

Fissure Vein—See *Vein.*

Fjords—Deep narrow arms running in from the sea. They are very numerous on the coasts of Norway, Greenland and eastern Labrador.

Flaggy—Capable of being split into parallel-faced slabs thicker than slates.

Float—Applied to loose pieces of ore, etc., which have been removed from their parent site by some natural process.

Floor—A horizontal rock-surface left by a joint or bed; the bottom of a drift or other working in a mine.

Flora—The plants collectively of a given age or region. See *Fauna.*

Flour-gold—Very fine gold dust.

Flouring—The coating of quicksilver with what appears to be a thin film of some sulphide, so that when it is separated into globules these refuse to reunite. The same trouble is also called "sickening."

Flucan—A layer of clay between a vein and the wall-rock, supposed to have been formed by the grinding of the two surfaces upon each other owing to slow movements extending throughout a great length of time.

Flume—A wooden trough, sluice or race for conveying water.

Fluorspar—Fluoride of calcium; a mineral which often forms veinstone and is usually finely colored-green, purple, yellow, blue, etc. It is the fourth in the scale of hardness, or next higher than calcite, and may be scratched by a steel point. It is common in veins in the Thunder Bay district.

Flutings—Smooth gutter-like channels or deep smooth furrows worn in the surface of rocks by glacial action.

Fluviatile—Pertaining to rivers.

Flux—In metallurgy, any substance added to facilitate the smelting of another.

Foliated—Leaf-like. The meaning is similar to that of laminated, but the latter is now generally used to indicate a finer or more parallel division into layers, foliated being applied rather to the approximate parallelism of the layers in such rocks as gneiss and schist.

Foot-wall—The rock on the lower side of a vein which underlies from the perpendicular.

Foraminifera—Minute marine animals of the lowest and simplest organisation, but having beautiful shelly coverings.

Formation—"Any assemblage of rocks which have some character in common, whether of origin, age or composition."—*Lyell.* In chronological geology formations constitute as it were the units, and several formations may go to make up a system (See Section I.) The word is often loosely used to indicate anything which has been formed or brought into its present shape.

Fossil—Although this word means literally anything "dug up," it is now restricted to organic remains, and it has become improper to speak of any mere mineral substance as a "fossil."

Fracture—The character or appearance of a freshly broken surface of a rock or mineral. Peculiarities of fracture afford one of the means of distinguishing minerals and rocks from one another.

Fragmentary Rocks—Rocks composed of fragments, whether large or small, broken from pre-existing ones. See *Clastic.*

Freestones—Varieties of sandstone which may be freely dressed by the stone-cutter.

Friable—Easy to break, or crumbling naturally.

Fucoids—Fossil sea weeds; abundant among Silurian strata.

Fundamental Rocks—Those forming the foundation, substratum, basis or support of others. In Ontario there is a great break or gap between the ancient or fundamental rocks and the superficial deposits which rest upon them.

Fuse—A stiff cord filled with gunpowder, etc., used for conveying fire to explosives after they have been properly set in the rock for blasting.

Gabbro—An igneous rock consisting of a crystalline granitoid mixture of a triclinic felspar and diallage, the latter being a variety of augite with perfect cleavage in one direction.

Gad—A small wedge for splitting rock. A similar tool used by quarrymen is called a plug.

Galena—The commonest ore of lead, of which it is the sulphide. When freshly broken it has a bright silvery appearance, from which it has been called lead-glance. It crystallises in the cubic system. Galena always contains more or less silver; too little to extract profitably in the majority of cases.

Gallery—In mining, a drift, tunnel or level for extracting the mineral or proving the vein or bed.

Gangue—The veinstone, veinstuff or matrix of a vein in which the metallic contents are enclosed. The commonest gangues are quartz, calcspar, fluorspar, barytes, etc

Gash-vein—A vein which terminates in every direction.

Geodes—Rounded hollow nodules; the cavities are usually lined with crystals.

Geology—"The science which investigates the history of the earth."—*Geikie.*

Geyser—Hot springs which occasionally throw up boiling water like fountains. They occur in Iceland and the western states of North America.

Glacier—A large accumulation of ice formed from snow falling upon high land and gradually sliding to lower levels. When a glacier reaches the sea it gives rise to icebergs.

Glance—A term formerly used to designate various minerals having a splendent lustre, as silver-glance, lead-glance, etc.

Gneiss—A foliated crystalline rock of a general granitoid composition. The commonest varieties are mica-gneiss, consisting of felspar, quartz and mica, and hornblende-gneiss, consisting of felspar, quartz and hornblende.

Gossan—A ferruginous crust filling the upper parts of pyritous veins or forming a superficial cover on masses of these ores. It consists principally of hydrated oxide of iron, and has resulted from the oxidation and removal of the sulphur as well as the copper, etc.

Granite—A homogeneous crystalline granular mixture of felspar (mostly orthoclase), quartz and mica, showing no foliation or tendency to break in one direction more than another. It may still be called granite even if little or no mica be present. Granites may have been of igneous origin, cooled under great pressure far below the surface of the earth as it existed at the time, or they may be the altered form of other rocks.

Granite Family—The group of crystalline, homogeneous or non-foliated rocks resembling granite, such as syenite, quartz-syenite, granitite and all varieties of granite itself.

Granitelle—Binary granite, composed of felspar and quartz.

Granitite—A mixture of orthoclase and oligoclase with a little quartz and mica.

Granitoid Rocks—The granite family includes rocks which have a general resemblance to granite, such as syenite, quartz-syenite, granulite, granitite, granitelle, massive gneiss, etc.

Granulite—A schistose rock composed of orthoclase and quartz with garnet and kyanite (a silicate of alumina) as accessory minerals. Granulite may be of eruptive origin notwithstanding its schistose character.

Graphic Granite—A variety of binary granite in which the quartz is disposed in the felspar in such a way that in cross section it has some resemblance to Hebrew and Arabic writing, and from this circumstance it derives its name.
Graphite—Called also black lead and plumbago, because it can be used for marking like lead, although this metal does not enter into its composition. It consists of pure carbon, with a slight admixture of iron.
Grass-roots—A miner's term equivalent to the surface.
Grating—The plate of perforated metal or sieve fixed in the openings in mortar or stamper boxes in gold or silver crushing mills.
Greenstone—A general name for the crystalline granular trap rocks such as diorite, diabase, basalt, etc., and is a convenient term for use in the field where it is difficult to distinguish these rocks from one another. Trap has too wide a range of meaning.
Greywacke—A gray ashy looking rock, consisting of a mixture of grains of felspar and quartz with some amorphorus mineral and often containing rounded and angular fragments of all sizes, from that of peas up to boulders, of a quartz-felspar rock. These are often so abundant as to constitute a breccia-conglomerate. Greywackés are very common rocks in the Huronian system from the shore of lake Huron northward.
Grit—Sandstone in which the grains are sharper or more angular than usual.
Group—See page 3.
Gully—A small valley with steep sides, usually cut out of clay or earth.
Gypsum—Sulphate of lime, usually white and crystalline, granular. Selenite is the pure crystalline form and splits into plates which are very transparent. It is very soft and is the mineral which constitutes the second degree of hardness, talc being the first. Gypsum occurs in beds on the Grand river in southern Ontario and on the Moose river in the northern part of the province.
Hæmatite or Hematite—One of the commonest ores of iron. It is the peroxide or sesqui-oxide, and when pure contains about 70 per cent. of metallic iron and 30 of oxygen. It may be readily distinguished from magnetic and titaniferous iron ore by its red streak and powder, the others giving a black streak. Hematite is sometimes mixed with sufficient magnetite to cause it to adhere to the magnet. The hydrated variety of this ore is called limonite or brown hematite, the anhydrous being often distinguished as red hematite. It contains about 14 per cent. of water and gives a brown or yellowish streak. It is not always compact—yellow ochre, bog iron ore, umber, terra sienna, etc., being varieties of it.
Hanging-wall—The wall rock on the upper side of a vein which underlies from the perpendicular.
Hardness of Minerals—Mineralogists have adopted a conventional scale of hardness for minerals. It is divided into ten degrees and the following minerals are used for reference as standards: 1 Talc, 2 Rock-salt, 3 Calcspar, 4 Fluorspar, 5 Apatite, 6 Orthoclase felspar, 7 Quartz, 8 Topaz, 9 Corundum, 10 Diamond. There is no scale of hardness for rocks, which are generally composed of mixtures of different minerals, but some varieties may be referred approximately to the scale for minerals.
Heave—A miner's term for an up-throw. See *Dislocation.*
Heavyspar—Barytes or sulphate of barium. Celestine or sulphate of strontium is also a heavyspar easily mistaken for barytes. The carbonate of barium is witherite; that of strontium is strontianite.
Height-of-Land—See *Water-shed.*
Hematite—See Hæmatite.
Hexagonal—Having six angles, and consequently six sides. Basaltic columns and crystals of quartz, apatite, etc., are examples.
Hopper—A box in the form of an inverted pyramid and having an opening at the apex, used for directing broken rock, earth, etc. to a contracted space in the manner of a funnel.
Horizon—In geology, refers to the age or place of rocks in the chronological scale. A rock is spoken of as belonging to a higher or lower horizon according as it is newer or older than some other rock.
Hornblende—A very common mineral; so called from its hornlike cleavage and its lustre; also known as amphibole and amphibolite by the French. Usually dark green and blackish, but occasionally of light colors. It enters largely into the composition of diorite, rendering this rock very tough. It is also a constituent of syenite, some gneisses, etc. It is a silicate of magnesia and lime, and its chemical composition differs but little from that of pyroxene or augite, this mineral being distinguished from it by crystalline form, etc. The principal varieties of hornblende are tremolite, actinolite and true asbestos.
Hornstone—The cherty and chalcedonic varieties of quartz.
Horse—A mass of country rock enclosed in a vein and almost or entirely surrounded by the vein stuff; sometimes called boulders.
Hummocky—Lumpy, or in small uneven knolls.
Huronian System—The great system of azoic or crystalline rocks lying between the Laurentian (below) and the Cambrian system (above). This name was first given by Sir William Logan and Dr. T. Sterry Hunt to these rocks as they were largely developed on the north side of lake Huron, but the term has been pretty generally adopted for rocks of corresponding age all over the world. See page 16.
Hydrated—Containing water in chemical combination, and hence in a definite proportion in each case, as gypsum which contains "water of crystallisation," hydrate of lime, or lime which has absorbed water on slacking, hydrated oxide of iron, or yellow ochre, which can be readily converted into the anhydrous or red oxide by driving off the water by heat.

Hydraulic Cement—Cement which sets under water. The rocks which, on being calcined and ground very fine yield this cement must contain in addition to lime certain proportions of alumina, silica and magnesia. A little iron is also usually present.

Hydraulic Mining—Washing down gold-bearing earth by means of a large and powerful jet of water brought from a considerable height and directed by a hose-pipe so as to have a pressure of from 50 to 100 pounds to the square inch. This process has been extensively used in California and has also been tried in the Chaudiere gold region of the province of Quebec.

Hydro-carbons—Substances composed of hydrogen and carbon, as bitumens, paraffine, petroleum, benzine, etc.

Hypogene—A term proposed by Lyell for all nether-formed rocks, *i.e.* rocks which have assumed their present form at great depths beneath the surface, whether originally stratified or unstratified. The former belong to the metamorphic and the latter to the plutonic group.

Iceland-spar—The transparent variety of calcspar, found in perfection in Iceland. It possesses the property of double refraction of light. If a dark line be viewed through it, it will appear as two parallel lines.

Igneous—Connected with subterranean heat. Igneous rocks are those which have evidently been once in a molten condition. Those which have cooled at and near the surface, such as lava and amygdaloid are called volcanic rocks, while those which have cooled at depths and under great pressure, such as granite, syenite, diorite, etc., are called plutonic rocks.

Ilmenite—Titanic iron or menacconite; a black heavy mineral like magnetite and composed of black oxide of iron with a varying quantity of oxide of titanium. It occurs similarly to magnetite. The black iron ores associated with the plagoiclase or triclinic felspar rocks appear to be prone to contain titanium. No profitable process has yet been discovered for the extraction of iron from ores containing more than a very small percentage of titanium.

Impervious—Impassable; applied to strata such as clays, shales, etc., which will not permit of the penetration of water, petroleum or natural gas.

Impregnation—When a substance, such as an ore, has been introduced into a rock in a disseminated form, it is said to be an impregnation; a diffused mixture, a sprinkling incorporated in the mass.

Indurated—Hardened; applied to rocks hardened by heat, pressure, or the addition of some ingredient not commonly contained in the rock referred to, as marls indurated by carbonate of lime.

Infiltration—The deposition of matter among the grains or pores of a rock by the permeation or percolation of water carrying it in solution.

Inorganic—Not organic; unconnected with animal or plant structure.

In situ—In position or place; applied to solid or fixed rocks as opposed to those which are loose and may have been transported.

Inspissated—Thickened as by evaporation and oxidation, as for example the pitch or gum resulting from petroleum after long exposure.

Intercalated—In geology means interposed or placed between, as beds of one kind placed between or interstratified with those of another kind.

Interstratified—Or interbedded. Strata laid between or alternating with others.

Intrusive—Applied to igneous rocks which have been forced between or into the midst of others.

Iridescent—Colored like the rainbow. A play of colors such as is seen on the peacock's tail. Labradorite and some other felspars show it. The tarnish on the surface of coal, copper-pyrites, etc., is sometimes iridescent.

Iron Pyrites—Or simply pyrite; bi-sulphide of iron. A hard, heavy, shiny, yellow mineral, generally in crystals of the cubic system. It may be distinguished from copper pyrite by being of a paler yellow color, harder and giving a black powder, whereas copper pyrites gives a yellow powder. When struck by steel or when two pieces are struck briskly together sparks of fire are emitted, accompanied by the odor of sulphur. A very common mineral. Marcasite has the same composition, but is white and crystallises differently. Pyrrhotite or magnetic pyrites is the monosulphide of iron and is of an iron-gray to bronze color.

Ironstone—Any ore of iron from which the metal may be smelted commercially, but usually restricted to stratified ores, especially to clay-ironstone—the ore from which most of the iron of Great Britain has been made.

Isoclinal—Applied to strata which have been so completely overturned that the upper fold or inverted portion dips in the same direction as the corresponding lower portion.

Jasper—Compact opaque varieties of quartz with conchoidal fracture and usually capable of a high polish. The colors are red, brown, green spotted, nearly white, etc.

Jigging.—One of the operations in the dressing of crushed ores, such as those of lead, copper, etc. The usual process consists in shaking or jerking the ore in a wire-bottomed sieve suspended in a vat of water. This allows the fines to pass through and they are afterwards treated in buddles, while the rest becomes sorted according to its relative gravity. The waste fragments are scraped off the top, the process being called skimping.

Joints—The nearly vertical division-planes which traverse nearly all rocks. They are called backs by quarrymen.

Jumper—A short steel drill for boring holes in rock for blasting or for splitting by gads.

Jurassic System—The system which succeeds the Triassic; so called after the Jura mountains on the border between Switzerland and France. It corresponds with the Oolite of England.

Kames—Ridges of sand and gravel of which the stratification is rudely parallel to the slopes of the surface. Their origin has not been satisfactorily accounted for.
Kaolin—Clay, usually very light in color, derived from the decomposition of the felspar in certain granites. It is used for the manufacture of porcelain.
Kibble—A large barrel-shaped bucket strongly bound with iron hoops, hung by a rope and used for hoisting ore, etc., up shafts in mines.
Kies—The pure or separated sulphides, as distinguished from the vein-matter in bulk.
Kiln—A large receptacle for calcining ores, limestone, etc.
Kindly—A miner's term for a rock which is considered congenial or likely for carrying ore.
Labradorite—Lime-soda felspar; a silicate of alumina, lime and soda. Crystallisation, triclinic. See *Felspar*.
Laccolite—A mass of igneous rock which has not reached the surface, but has been forced between two beds of rock where it has spread out. Examples occur in the Thunder Bay region.
Lacustrine deposits—Deposits formed in the boottom of lakes.
Land-slides or slips—Large masses of clay, earth or rock which have lost their support and slid down, sometimes temporarily blocking up streams.
Launder—A spout or trough for carrying water for a short distance.
Laurentian System—See description, pages 8-16.
Lateral—Belonging to the sides, or to one side.
Lead—An auriferous deposit following the former bed of a stream now covered by superficial deposits. In Nova Scotia quartz veins are called leads.
Lean—Applied to poor ores, or those containing a lower percentage of metal than is usually worked.
Lenticular—Shaped approximately like a double convex lens. When a mass of rock thins out from the centre to a thin edge all round it is said to be lenticular in form.
Level—See *Drift*.
Lignite—See *Coal*.
Limestone—A rock composed of carbonate of lime; of all colors and varies in texture from compact or amorphous to coarsely crystalline. White marble is a finely crystalline variety. Chalk is a soft form. Limestone may be distinguished from other rocks by being easily scratched with a knife and by effervescing when acid is placed upon it.
Limonite—Brown hematite; hydrated oxide of iron. See *Hematite*.
Lithology or Petrology—The study of rocks as such; a branch of geology which is being much developed in recent years. By making thin sections and examining them under the microscope the nature of a rock may be determined as well for most purposes as by chemical analysis.
Loam—A mixture of sand and clay. If decayed vegetable matter be added, it assumes a dark color and is called vegetable loam.
Lode—A metalliferous vein.
Loess—A peculiar deposit like fine silt found in some parts of northern Europe, northern China and in the north-western United States.
Long-Tom—A trough for washing gold-bearing gravel or earth.
Lustre—The character of the light reflected by minerals; it constitutes one of the means of distinguishing them.
Lydian-stone—A compact or close grained, nearly black, variety of jasper. A smoothed surface of this stone is used for trying the streak of gold, the color of which affords an index to its purity.
Macroscopic—Readily seen by the naked eye. On a large scale compared with microscopic.
Magnesian Limestone—See *Dolomite*.
Magnetic Iron Pyrites—See *Iron Pyrites*.
Magnetite—Or magnetic iron ore. Black oxide of iron. In addition to its magnetism it may be distinguished from hematite by yielding a black streak and powder.
Maltha—The pitch or "gum" resulting from the drying up and oxidation of petroleum, as when it has reached the surface of the ground.
Mammillated—Having the form of paps or breasts.
Mammoth—A fossil elephant allied to the living species, but larger.
Manganese—A metal chemically related to iron. The black oxide, pyrolusite, the gray oxide, manganite and the earthy oxide, wad, are used in the arts. Manganese is used in the manufacture of Bessemer steel.
Massive Rocks—Those which have no stratification or lamination, as greenstones, granite, syenite, etc.
Marble—A variety of moderately soft rocks capable of taking a good polish are called marble. The commonest are compact and crystalline limestones and dolomites and serpentine.
Marcasite—See *Iron Pyrites*.
Marl—Usually applied to a soft or friable natural mixture of clay and lime.
Marly—Resembling marl.
Mastodon—A genus of extinct elephantine mammals, having conical protrusions on the grinding surfaces of their teeth, whereas the mammoth has flattened transverse ridges.
Matrix—The body or "paste" of any rock which encloses fragments or crystals.
Measures—A general name for stratified rocks.
Mesozoic—Or Secondary; the "middle-life" Period or Age. It is the third of the five grand divisions of geological time. It includes (in ascending order) the Triassic, Jurassic and Cretaceous systems.
Metalliferous—Carrying metal.
Metamorphic—Applied to rocks which have been changed in form and internal structure. Heat, pressure and time acting on the constituents of rocks have been the main

causes of metamorphism, converting ordinary and soft sedimentary deposits into crystalline and hard rocks.

Metamorphism—The change in form, etc., which some rocks have undergone, or the process itself. Alteration has a somewhat similar meaning.

Meteorite—See *Aerolite*.

Mica—A common mineral easily recognised by its glistening appearance and from the fact that it may be split into very thin leaves which are elastic. It enters into the composition of mica-schist, gneiss, granite and other crystalline rocks, and is found in scales in sands and sandstones derived from their disintegration. Ignorant persons sometimes speak of it improperly as isinglass, which is made from the swimming-bladder of the sturgeon.

Micaceous—Containing mica or largely composed of it.

Mica-schist—A foliated crystalline rock composed of alternate layers of quartz and mica in various proportions, the typical one being about two-thirds quartz to one-third mica; although the proportion of the latter generally appears greater than it is, because the rock splits along the mica folia, thus showing the mica alone on the flat surfaces. The true composition may be seen by looking at the squarely broken edges.

Microscopic—So small as to be seen only by the microscope.

Millstone Grit—In Great Britain this name is given to a part of the Carboniferous system, consisting principally of sandstones, below the coal measures; it is also sometimes used for the equivalent group in America.

Mine—An excavation or series of excavations in the earth for the extraction of minerals. A mere discovery or outcrop of an economic mineral does not constitute a mine. It is the working of the deposit, not its mere existence, which does this.

Mineral—Scientifically, any inorganic substance having a definite chemical composition and crystallising in definite forms. Each of these constitutes a mineral species. See *Rock*. But the word means literally anything dug out of the earth, and in this sense includes everything except living or recently dead organic matter. Many mineral substances, such as coal, some limestones, etc., are composed of mineralised organic matter.

Mineralisation—The conversion of a substance into mineral, as peat into coal.

Mineralogy—The study or science of minerals; often confounded with geology, which see.

Miocene—The middle Tertiary system.

Molecule—An ultimate particle of matter, having a definite chemical composition.

Mollusca—One of the primary divisions or provinces of the animal kingdom; it embraces those soft-bodied invertebrates most but not all of which are provided with shells, as oysters, snails, slugs, etc.

Molybdenite—Sulphide of molybdenum—a soft bluish black, usually laminated mineral occurring in veins of quartz, etc., having somewhat the appearance of graphite, but in most cases yielding a dark green mark on white paper. If found in considerable quantity it has a commercial value.

Monocline—A bend in strata in one direction only.

Moonstones—Pale opalescent, almost transparent varieties of felspars.

Moraines—Piles or ridges of boulder-drift or till which have accumulated at the sides (lateral) or lower extremities (terminal) of glaciers.

MortarBox—The large deep cast-iron box into which the stamps fall and the ore is fed in a gold or silver stamp-mill; also called a stamper-box.

Moss Agate—A variety of agate showing branching forms like those of moss.

Mountain Cork—An extremely light non-fibrous variety of asbestos.

Mullock—A term sometimes used for the accumulated waste or refuse rock about a mine.

Naphtha—A highly volatile liquid form of hydrocarbon.

New Red Sandstone—The former name for the Permian system; it lies above the Carboniferous, while the Old Red Sandstone lies below it.

Nickel—One of the metallic elements. It is a white metal, having a lustre like silver, but in its chemical relations it is more nearly connected with iron; it is not, however, susceptible to oxidise like iron, and this is one of the properties which renders it so valuable for plating this metal. It has recently been found to give great toughness to steel, a most valuable property. Nickel is found most abundantly as a sulphide, associated with iron and copper.

Nodule—A concretion in a softer matrix, as the kidney-stones found in clays almost everywhere. The bombs or kettles in the black shales of the Kaministiquia and Whitefish valleys are only great nodules. The flints of the chalk of England and the detached lumps of clay-ironstone of the Carboniferous shales, etc., are other forms of nodules. Nodules have generally formed themselves around some fragment of either organic or inorganic matter as a centre or nucleus.

Nugget—A lump of native gold, silver, platinum, copper, etc.

Obsidian—Dark-colored volcanic glass, the product of volcanoes of later geological times. It is a silicate of alumina, potash, soda and lime.

Ochre—Naturally occurring pigments, as yellow ochre or hydrated oxide of iron. Blue, green, red, etc., clayey mixtures which may be used as coarse paints are also called ochres. Ochre is also used as a mineralogical term for certain decomposition oxides as bismuth, chrome, antimony and cobalt-ochres.

Old Red Sandstone—See *New Red Sandstone*.

Oligoclase—Soda-lime felspar; a silicate of alumina, soda and lime. Crystallisation, triclinic. See *Felspar*.

Olivine—An earthy looking olive-green mineral occurring in many trappean rocks.

Oolite—A limestone composed of small round grains resembling fishes' eggs, hence the name.

Opal—A gem composed of silica with from 5 to 10 per cent. of water having a "play of colors" or reflecting rainbow-like colors with a brilliance or "fire" that gives to sound pieces a great value. Generally white and having a hazy or milky translucency.
Opalescent—Resembling opal.
Open-cutting—Or open-cast. A cutting or excavation in a mineral deposit or for the purpose of reaching one.
Ore—Properly speaking, combinations of metals with other substances, but also applied to the matrix from which native metals such as gold, silver and copper are extracted. Sometimes also applied to other minerals won by mining, as apatite, barytes, etc.
Organic—Having organs for carrying on vital processes. Animals and plants are thus organised as distinguished from minerals or inorganic substances. When these organs or organic structures become mineralised they are fossils or organic remains.
Orthoclase—Potash felspar; a silicate of alumina and potash. Crystillisation, monoclinic. See *Felspar*.
Outcrop—See *Crop*.
Outlier—A portion detached from the main body, an island, as it were, surrounded by some other kind of rock.
Overlap—When strata extend over an ancient foundation further than those immediately preceding them, this extension is called an overlap.
Overturned—Where strata have been highly tilted till they pass the perpendicular, so that the lower fall becomes turned upside down, they are said to be overturned.
Oxide—A compound of the element oxygen with another element or other elements.
Palæontology—The study of ancient life, especially of animal remains, that of plant remains or fossil botany being called palæobotany.
Palæozoic—The second of the five grand divisions, periods, or ages of the rocks of the earth's crust; so called from containing evidences of the most ancient life on the planet. The Palæozoic période includes (in ascending order) the Cambrian, Silurian, Devonian, Carboniferous and Permian systems.
Paroxysm—In geology, any violent or sudden natural occurrence, as a volcanic eruption, a sudden flood, etc.
Parting—A thin layer separating greater masses of rock, usually beds, as a parting of shale between beds of sandstone or limestone.
Patchy—Distributed in patches or in an irregular manner as when ore occurs in bunches or sporadically.
Peat—A mass of vegetable matter formed in bogs and marshes. Its principal constituent is sphagnum moss, but rushes, reeds, sedges, grasses, algæ, etc., may also contribute. Peat sometimes accumulates to considerable depth; the lower portion becomes black and dense and is used for fuel. The rotten wood found in the bottoms of *swamps* is not peat, properly speaking
Pegmatite—A very coarse variety of granite, composed principally of quartz and crystalline felspar, but often holding sheets of mica. It usually forms great veins or enlargements of veins cutting mica-schist, gneiss, etc. Formerly applied also to finer mixtures of quartz and felspar, called binary granite, now known as granitite and quartz-felspar rock.
Permian System—The system next above the Carboniferous; formerly called the New Red Sandstone; the Devonian or next system below the Carboniferous being the Old Red Sandstone. This name (introduced in 1841 by Sir Roderick Murchison) is derived from the government of Perm in central Russia, where the system is well developed. There, as in the north of England, it is made up principally of red sandstones.
Petrify—To become stone. Organic substances, such as shells, bones, wood, etc., embedded in sediments, become converted into stone by the gradual replacement of their tissues, particle by particle, with corresponding amounts of infiltrated mineral matter. Thus not only the outward forms but even the minutest details of the organic tissues are preserved.
Petroleum—Or rock-oil; liquid hydrocarbon. Formed in large quantities in some rocks which contain organic matter.
Petrology—See *Lithology*.
Petrosilex—A compact silicious felsite, having a fracture like jasper but distinguishable from it in being fusible before the blowpipe.
Phenomenon—In science, any natural occurrence or appearance.
Phosphate of Lime—See *Apatite*.
Pillars—Portions of the vein or bed left standing to support the roof.
Pinched—Where a vein narrows, as if the walls had been squeezed in. When the walls meet the vein is said to be pinched out.
Pitchstone—A dark glassy or pitchy looking igneous rock, occurring as dykes, and also as beds which have flowed upon the former surface. It is a natural glass with splintery fracture, although translucent only on thin edges, and has the composition of felsite.
Placers—Gold-bearing sand and gravel deposited on the bed-rock.
Plagioclase—The triclinic felspars are called collectively plagioclase. The principal triclinic felspars are albite, anorthite, labradorite and oligoclase. As constituents of rocks they occur generally in small crystalline grains, and without a miscroscopic examination it is difficult to distinguish them in this form from one another; hence this term is very convenient for use in the field.
Plaster of Paris—A plaster made from gypsum by grinding and calcining it; so called from its manufacture near Paris in France. In Canada this term has been adopted for gypsum in any form.
Plastic Clay—In England, applied to certain clays of the Eocene system, but in general means clay suitable for moulding into any form.

Pleistocene System—Or Post-Pliocene. The system which succeeds the Pliocene. It embraces the remains of a few extinct species of animals, especially of mammals, while those of the Recent belong entirely to species still living.

Plicated—Folded together, as in highly inclined and contorted strata.

Pliocene System—The uppermost of the Tertiary systems; divided into the Older Pliocene, in which from 35 to 50 per cent. of its embedded species are still living, and the Newer Pliocene, in which the proportion is from 90 to 95 per cent.

Plumbago—See *Graphite*.

Plumbaginous—Containing plumbago, as plumbaginous schists; some crystalline limestones are also plumbaginous.

Plutonic Rocks—Igneous rocks which have cooled at a considerable depth from the surface and under great pressure. See *Igneous*.

Pocket—A single mass of ore which may be of any size. When a vein carries ore in isolated masses with much dead ground between them it is said to be pockety.

Porphyry—Any massive rock with crystals distinct from the matrix. Typical porphyries are however those which have a felspathic ground-mass or matrix with a compact or flinty texture and holding disseminated crystals of felspar. Quartz-porphyry contains a considerable proportion of quartz in addition to the felspar, and crystals of both minerals are scattered through it; but where no such crystals occur and the whole mass is compact, it forms a variety of felsite. Porphyry was originally applied to a red syenite with distinct felspar crystals from Upper Egypt, and all similar rocks are still included among the porphyries.

Porphyritic—Resembling porphyry.

Post Tertiary Period—Also called Quaternary. The newest of the five grand divisions of geological time. It includes the Pleistocene or Post-Pliocene and the Recent or Prehistoric systems, which bring us up to the present or historic time.

Pot-holes—Kettles; circular holes sometimes much deeper than wide, worn into the solid rock at falls and strong rapids, by sand, gravel and stones being spun round by the force of the current.

Potstone—A coarse or impure variety of soapstone; so called from being easy to cut into pots owing to its softness.

Precipitate—When a substance, held in solution in a liquid, is thrown down in a solid form by the addition of some other substance in solution, the resulting solid is called a precipitate. When a substance held only mechanically in suspension in a liquid settles to the bottom it is called a sediment.

Prill—A good sized piece of pure ore.

Primary—See *Palæozoic*.

Primitive—See *Archæan*.

Primordial—The name given by Barrande to the oldest fossiliferous rocks as developed in Bohemia. It corresponds with the British Cambrian.

Prospector—A person engaged in exploring for valuable minerals, or in testing supposed discoveries of the same.

Protogene—A variety of granite in which talc takes the place of mica; so called by the French, who supposed that it was the first-formed of the granites. The granites of Cornwall, England, which decompose and yield kaolin are of this kind.

Pseudomorph—False form; the name given to crystalline forms of a composition not proper to such forms. They may be mere casts, occupying cavities from which crystals have been dissolved, or they may have replaced other crystals particle by particle by some slow process.

Pudding-stone—Conglomerate.

Pumice—A very light porous and vesicular lava which will float on water; a sort of volcanic froth. Its color is generally whitish or light gray.

Pyrites—See *Iron Pyrites*.

Pyrolusite—Black oxide of manganese; used for making oxygen.

Pyro-schists—Bituminous shales which yield hydrocarbon oils and gases on distillation.

Pyroxene—See *Augite*.

Pyrrhotite—See *Iron Pyrites*.

Quartz—A common mineral occurring in a great variety of forms. It is composed of the elements silicon and oxygen. It crystallises in the hexagonal system. The transparent colorless variety, which is the purest form, is called rock-crystal. White or milk quartz is a very common vein-stone. Gold occurs most frequently with quartz, but only a small proportion of quartz veins contain gold. The numerous varieties of quartz may be classified in three groups: (1) the vitreous, like rock crystal, rose quartz, amethystine quartz, etc.; (2) the chalcedonic, like chalcedony, charnelian agate, flint, etc.; (3) the jaspery, like jasper, bloodstone, lydian stone, etc.

Quartzite—Quartz-rock; a rock composed of grains of quartz cemented, or as it were fused together by the same substance. Quarzites are indurated sandstones; they often contain grains of felspar. Among the Huronian rocks, great belts of quartzites occur from lake Huron north and northeastward, and on the northwest side of Hudson bay.

Quaternary—See *Post Tertiary*.

Quick-lime—When carbonate of lime (limestone) has been thoroughly calcined this results. By the addition of water it forms hydrate of lime, the process being called slaking.

Quicksilver—A common name for mercury; one of the metallic elements, remarkable for its low melting point, being liquid down to 40° Fah. below zero.

Race—An artificial canal for conveying water.

Range—A chain of mountains or hills; also a belt or strip of country within which certain economic minerals are supposed to occur or run.

Recent—The present geological time, although it extends back through a vast period of years. All or nearly all existing species of animals have lived throughout the Recent epoch.
Reef—In mining, often applied to quartz veins or veins of any kind; also to solid or fixed rock in general, as opposed to loose materials.
Resin—Mineral Resin; substances allied in composition to the resins of coniferous trees, such as amber.
Reticulated—A net-like arrangement.
Ribboned—When the stratification of rocks is very distinct or strongly marked on a small scale, as by contrast of colors, such as may often be seen in gneisses, they are said to be ribboned. When the lines of contrast are on a larger scale they are said to be banded.
Riddle—A box or vessel with a perforated bottom, used by alluvial gold miners for separating out the coarse gravel.
Rifles—See *Ripples.*
Ripples—Grooves or bars across sluices for washing gold.
Ripple-mark—The wavy surface of some beds of sandstones and mudstones, produced by gentle movement in shallow water when these rocks were in a soft condition.
Roches moutonnces—Rounded hummocks or bosses of rock like whales backs, smoothed and striated by glacial action.
Rock—Commonly used to indicate any stony substance occurring in nature, but geologists are obliged to extend its meaning so as to include almost everything which enters into the composition of the earth, even if the material be soft like marl, clay or sand. Rocks generally consist of mixtures of different minerals, although some, such as limestone, serpentine, quartzite, etc., are composed almost entirely of one mineral species. See *Mineral.*
Rock-Basin—A depression or basin-like excavation in the solid rock, sometimes of great extent. Nearly all of our numerous lakes, even the largest of them, are entirely surrounded by solid rock or lie in rock-basins.
Rock Crystal—Transparent, colorless quartz.
Rock-Salt—Common salt occurring in nature in solid beds or rock-masses.
Rotten-Stone—A soft light earthly substance, consisting of silica in fine grains, resulting from the decomposition of silicious limestone.
Royalty—A rate or duty payable to the Government or to individuals on the produce of a mine.
Rutile—A mineral consisting of oxide of titanium. It is found associated with titaniferous iron ores and occasionally in mica-schist, granite, etc.
Sandstone—Rock composed of sand more or less consolidated or cemented together.
Saccharoidal—Having the texture of loaf sugar, as fine-grained crystalline limestone or marble.
Scale of Hardness—The relative hardness of minerals is one of their most convenient tests. There are ten degrees. See *Hardness.*
Schist—Crystalline foliated rock, splitting into irregular lenticular or wedge-shaped plates. There are many kinds of schist, such as chloritic, talcoid, dioritic, mica, hornblende, etc. See *Slate* and *Cleavage.*
Seam—This word was once used to indicate the divisional plane or line between beds of rock; it now applies to the bed itself. It usually indicates a bed of a different kind from the others with which it is associated, as a seam of coal.
Secondary—See *Mesozoic.*
Section—In geology either a natural or an artificial rock-cut, or the representation of such on paper.
Secular—Relating to an age or vast period of time.
Sediment—Any matter such as mud, sand, etc., which has settled down from suspension in water. Most stratified or sedimentary rocks have been found in this way, although some, as certain limestones and dolomites, have been precipitated. See *Precipitate.*
Segregation—A process by which mineral matter has been transfused or exuded into veins and openings, especially in crystalline rocks.
Selenite—Gypsum in transparent crystals.
Septum—A division or partition, such as those in an Orthoceras.
Sequence—Following, succession, coming after, continuation.
Sericite—A talc-like hydrous mica (muscovite) occurring in small scales and forming sericitic schist, which is also called talcoid schist, and often spoken of by prospectors as talcose schist, but this term properly applies to schists composed largely of talc, which are much rarer.
Series—In geology, a group of rocks in a certain order or succession, or a set of beds having something in common. See page 3.
Serpentine—A compact rock, rather soft or sectile, with a conchoidal and splintery fracture and waxy lustre. When powdered has a greasy feel. Capable of a high polish and is called marble. Translucent on thin edges. In color, it has various shades of green, generally dark and leek-green, often spotted or veined; these are called verd-antique; also brown, red, yellowish, etc. Composed of hydrated silicate of magnesia and a little iron. The name has reference to its colors, suggestive of those of snakes.
Shaft—A deep pit or hole sunk through earth or rock for the purpose of reaching minerals. Shafts are generally rectangular in cross section, and perpendicular or approximately so. If they underlie far from the perpendicular they are called slopes.
Shale—Fissile argillaceous rock, splitting with the bedding as distinguished from slate, which cleaves in parallel planes independent of the bedding. Shales are generally softer than slates. There are many varieties, as ordinary argillaceous or clayey shale, bituminous (like the Utica) shale, arenaceous, ferruginous, calcareous, etc.

Shaking-Table—A slightly inclined table t › which a lateral shaking motion is given by means of a small crank or an excentric. Water is allowed to flow over them and they are covered with copper plates coated with mercury for the purpose of amalgamating gold or silver. They may also be provided with ripples and used in separating alluvial gold.
Shell-Marl—A light colored calcareous deposit in the bottoms of small lakes, composed largely of dead fresh water shells, but apparently also to some extent of precipitated carbonate of lime and the hard parts of minute organisms ; used for manure.
Shift—The time during which one set of men works in a mine. There are usually two shifts of 10 hours each in the 24 hours, but when great expedition is required three shifts of 8 hours each may be worked.
Shingle—Rounded stones and pebbles larger than gravel and smaller than boulders, forming ancient or modern benches.
Shoot—An inclined wooden spout or slide for sending down ore or rock ; also the richest ore-streaks in a vein, which in the profile of the vein may run at any angle to the horizon.
Sickening of Quicksilver—See *Flouring.*
Silica—Silex. The same in composition as quartz ; used more frequently in chemical language for this substance
Silicious—Relating to silica.
Silicified—Made into silica. Organic remains, both plant and animal, are often thus convert d.
Silt—Mud, fine sand, etc., deposited in harbors, estuaries, lagoons, etc., from the slacking of the currents which had borne them along.
Silurian System—The second system, in ascending order, of the Palæozoic period. See page 40.
Sink-holes—When rocks such as salt, gypsum or limestone have been locally dissolved away, the earth may sink and form a cup-shaped basin, to which this name is given.
Sinuous—Curving, winding.
Skid—A wooden beam, scantling or other timber used for sliding heavy weights upon.
Skimping—See *Jigging.*
Slab—A wide flat stone ; the outside cut off a log of wood in sawing it into planks.
Slide—See *Fault, Dislocation.*
Slikensides—A miners' term for the smoothed and striated surfaces often found on the walls of veins and in faults, produced by the movement or rubbing of one mass of rock on another, under great pressure.
Slip—See *Fault* and *Dislocation.*
Slope—See *Shaft.*
Sluice-Box—A long trough or flume with ripples for catching alluvial gold when the earth is washed down it by water.
Spar—Crystalline veinstones which break along cleavage planes, as calcspar, fluorspar, felspar, bitterspar, heavyspar, etc.
Specific Gravity—In regard to solids, means their weight relatively to an equal bulk of water at a temperature of 60° Fahr.
Specimen—Properly speaking, a sample of anything ; but among miners it is often restricted to selected or handsome minerals, as fine pieces of ore, crystals, or pieces of quartz containing visible gold.
Specular—Mirror-like, as specular iron ore, a variety of hematite.
Spur—An offshoot or branch vein ; a subordinate range of hills or mountains connected with a main chain.
Stalactites—Tapering, or icicle-shaped projections of travertine hanging from the roofs of caves or fissures formed by the dripping of lime water.
Stalagmites—Of the same composition and form as stalactites, but have grown upward from floors of caves, etc., on which lime-water has dripped.
Stamper Box—See *Mortar Box.*
Stamp Head—A heavy and nearly cylindrical cast iron head fixed on the lower end of the stamp rod, shank or lifter to give weight in stamping the ore. The lower surface of the stamp head is generally protected by a cheese-shaped "shoe" of harder iron or steel which may be removed when worn out. These shoes work upon "dies" of the same form laid in the bottom of the mortar or stamper box.
Stamp Mill—A mill for stamping ores ; used for reducing those of gold, silver, tin, copper, etc.
Stanniferous—Carrying tin.
Steatite—Or soapstone ; a massive variety of talc ; a very soft rock having a soapy or greasy feel ; it is a silicate of magnesia with a little water.
Stockwork—Or Stockwerke. A thick mass of reticulating metalliferous veins, the country-rock between them being also charged with pockets and impregnations of ore. Stockworks have seldom any great length in proportion to their width. They may be described as indefinite aggregations or accumulations of ore of a general lenticular form, but apt to recur, especially in depth as if connected with some line of fracture.
Stone Age—The period when man used implements of stone instead of metal.
Stone of Ore—A piece of ore.
Stoping—When a mine has been opened by sinking shafts and driving levels (called simply "sinking and driving") the next process is to stope out the ore, which consists in excavating it either upward from the roof of each level, called overhand stoping, or downward from the floor, called underhand stoping. The latter requires all the material to be removed out of the mine, whereas by the overhand process the refuse may be left su orted on stulls or flooring made of timber.

Stratification—Relating to the arrangement in strata or layers.
Stratigraphy—The description of stratigraphical arrangement, or its delineation on a map.
Stratum—A bed or layer of rock; strata, more than one layer.
Streak—The color of a mineral when scratched. When a mineral is rubbed on a surface of unglazed porcelain the streak is well brought out.
Striæ—Fine parallel lines, either grooves or ridges.
Strike—The course or bearing of the outcropping edges of inclined strata in reference to the horizon, or in other words the strike is the intersection of the plane of the bedding with the horizontal plane. It is therefore at right angles to the dip.
String—A very small vein, either independent or occurring as a dropper or branch of a larger vein.
Stripping—Removing the earth or rubbish from the outcrop of a vein or from any rock-surface.
Structure—The arrangement of rock-masses, such as their being bedded, jointed, slaty, schistose, basaltic, columnar, etc.; also the attitude of rocks and their positions relatively to each other.
Stull—The platform or flooring of timber fixed between the walls of a mine in overhand stoping for receiving the refuse rock.
Subsidence—A sinking down of a part of the earth's crust.
Sump—A deepening at the bottom of a shaft to receive the drainage of a mine, and from which the water is pumped.
Superficial Deposits—Deposits forming the surface, mostly of a soft or incoherent character. In Canada they include the Pleistocene or Post-Pliocene and Recent deposits.
Superposition—The order in which rocks are placed above one another.
Surface Geology—The geology of the superficial deposits and of the surface of the fundamental rocks.
Swab-stick—A stick frayed out at one end; used for cleaning the sludge out of holes in process of being bored for blasting.
Syenite—Originally applied to a reddish crystalline granitoid rock from Syene in Egypt, consisting of felspar, hornblende and quartz, now called quartz-syenite, while syenite has come to mean a crystalline granitoid rock consisting of felspar and hornblende without quartz.
Synclinal—When stratified rocks dip from opposite sides towards a common line the arrangement is called a synclinal; the reverse of anticlinal.
System—A great series of strata having some general character in common. As a division of the rocks of the earth's crust, the system ranks next above the formation in comprehensiveness. Formations are somewhat local divisions and many of them can only be recognised in one country, whereas the systems are sufficiently comprehensive to be recognised in all parts of the world. The systems in ascending order are Laurentian, Huronian, Cambrian, Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene, Miocene, Pliocene, Pleistocene and Recent. See p. 3.
Tailings—The fine waste material from jiggers and crushing mills. That from the latter is carried out by water and is as fine as sand.
Tail-race—The channel for carrying off the spent water of a mill or from a washing process.
Talc—A very soft mineral, being 1 in the scale of hardness; occurs in laminæ like mica, but is not elastic; has a pearly lustre and greasy feel; prevailing color, greenish; is a silicate of magnesia; enters into the composition of talcose schist, soapstone or steatite, the variety of granite known as protogene, etc.; is used in the manufacture of crayons, crucibles and porcelain.
Talcoid—Resembling talc, as talcoid schist. See *Sericite.*
Talcose—Containing talc; as potstone, steatite and talcose-schist.
Talcose Granite—See *Protogene.*
Talus—In geology, the sloping mass of fallen rocks accumulated at the base of a cliff or precipice.
Tamping—The crushed rock or other material which is hammered tightly down over the explosive in a drill hole for blasting.
Tamping Bar—An iron bar, shod with copper to obviate striking fire, used for driving down the tamping.
Tar—Soft pitch or thickened petroleum, found in cavities of some limestones, as those of the Corniferous formation in Ontario, also in those of the township of Keppel west of Owen Sound. Along some parts of the Athabasca river, in the North-west territory, much mineral tar has exuded from the rocks.
Terra Cotta—The "baked earth" of the Italians. Kiln-burnt clay assuming a peculiar reddish-brown color fashioned into vases, statuettes and other mouldings.
Terra Sienna—See *Ochre.*
Terrace—A nearly level shelf of land abutting on higher ground and dropping off suddenly on the lower side. This steep bank is due to the former wearing action of some body of water which cut it away.
Terrain—A group of strata, a zone, or a series of rocks. This word is used in the description of rocks in a general, provisional or non-committal sense.
Tertiary Period or Age—Also called the Cainozoic. The third grand division of geological time above the Azoic or the fourth in all. It comprises (in ascending order) the Eocene, Miocene and Pliocene systems.
Tessellated—A surface divided in squares, or figures approaching squares, by joints or natural divisions.
Texture—The coarseness or fineness, character, arrangement, etc., of the component grains or particles of a rock.
Thread—An extremely small vein, even thinner than a string.

Throw—See *Fault* and *Dislocation.*

Till—The Scotch name for hard-pan, boulder-clay, or the unstratified stony clays of the drift formation; a convenient term now generally adopted by geologists for these deposits.

Titaniferous—Carrying titanium, as titaniferous iron ore. See *Ilmenite.*

Titanite—Or sphene; a mineral consisting of silicate of titanium and lime, generally darkly colored, occurring among the Upper Laurentian rocks.

Tourmaline—A mineral occurring in long, usually striated prisms in the ancient crystalline rocks; generally dark in color, harder than quartz and complex in composition, but consisting principally of silicate and borate of alumina with some iron, magnesia, lime, fluorine and different alkalies.

Trachyte—A volcanic rock or lava common in Tertiary and Post-Tertiary times, consisting principally of a glassy variety of orthoclase called sanidine and some triclinic felspar, together with hornblende, mica, magnetite, etc. It is characterised by its rough fracture.

Transition—Intermediate. A term used by the older geologists for rocks which came between their better defined divisions; but little used at present.

Translucent—Admitting the passage of light, as milk-quartz, but not capable of being seen through.

Transparent—That may be seen through, as rock-crystal, Iceland-spar, selenite, etc.

Trap—A general term for igneous rocks, such as the greenstones, basalts, amygdaloids, most porphyries, etc., but too indefinite for modern geological language.

Tremolite—A variety of hornblende in radiating or columnar aggregates, generally light colored, with pearly lustre.

Triassic System—The first or lowest system of the Mesozoic or secondary period.

Trilobites—A family of crustaceans, so named from their bodies as viewed from above being divided longitudinally into three lobes. They embrace many genera and species; are most abundant in the Cambrian and Silurian systems, dying out in the carboniferous; so that rocks in which the remains of these creatures are common may be pronounced to be below the coal-bearing strata.

Tributer—One who works a mine or mineral deposit for a share of the product.

Trouble—See *Fault.*

Trough—In geology, synonymous with *Basin* and *Synclinal*, which see.

Truck—A small tram-car for carrying coal, rock or ore along a level in a mine, or out to a shoot or a dump. Also goods paid instead of money for wages.

Tufa—Any open, porous or vesicular mass, as volcanic tufa, calcareous tufa, etc.

Tunnel—A level driven from the side of a hill, etc., into a mine, or driven within the mine; equivalent to adit, level, gallery, etc.

Truncated—Cut or broken off abruptly.

Turtle-Stones—Large nodular concretions found in certain clays and marls. In form they have a rough resemblance to turtles, and this appearance is increased by their being divided into angular compartments by cracks filled with spar, reminding one of the plates on the shell of a turtle. They are common in the cretaceous marls of the North-west territories.

Unconformable—See *Conformable.*

Unctuous—A greasy feel such as that of soapstone, powdered serpentine, certain clays, etc.

Underlie—The inclination of a vein from the perpendicular, whereas dip is the inclination of a bed from the horizon.

Undisturbed—Rocks which lie in the positions in which they were originally formed. See *Disturbed.*

Univalve—A mollusk having a single shell. A bivalve mollusk has two shells.

Unstratified—Rocks which are not in beds or strata, as granite, syenite, greenstone, etc.

Upheaval—A lifting up, as if by some force from below, of stratified or other rocks.

Upthrow—An upward displacement of rock along a line of break or fissure.

Vein—A fissure, a contact-space, or a gash which has been filled with mineral matter. After a rent or fissure has been formed in solid rock, there is usually some dislocation, so that a space is left between the walls. This gives rise to the fissure vein. Similarly a movement or dislocation along the contact of two different kinds of rocks gives rise to the contact vein. A gash vein terminates in a thin edge in all directions or has a lenticular form, and is only exposed so that it may be discovered by a natural section of the rock formed either by the surface of the ground or by a cliff.

Veinstone—The mineral matter filling a vein, exclusive of the ore. See *Gangue.*

Veined—Marked or streaked with veins or lines of color in various directions, as some marbles.

Verd-antique Marble—A variety of green serpentine with patches and veins of white calcspar and capable of a fine polish. Abundant in the Eastern Townships, province of Quebec.

Vermilion—A bright red pigment consisting of the sulphide of mercury. See *Cinnabar.*

Vertebra—A joint of the backbone of any vertebrate animal.

Vertebrata—One of the provinces or primary divisions of the animal kingdom.

Vesicular—Containing little bladder-like cavities, such as some lavas.

Vitreous—Like glass.

Vitrify—To make like glass.

Volcanic—Pertaining to volcanoes. Volcanic rocks are those of igneous origin formed at or near the surface, such as lava, amygdaloid and volcanic ash; whereas igneous rocks formed at a depth and under pressure are generally crystalline and are called plutonic. See *Igneous.*

Walls of a Vein—See *Foot Wall*; also *Hanging Wall.*

Wash Dirt—Gold-bearing earth worth washing.

Water-shed—The height-of-land or divide from which the natural drainage of a district flows in opposite directions.

Weathering—The change which the surface of a rock undergoes by exposure to weather.

Whim—A large drum for winding rope, revolving horizontally and kept in its place by a frame-work. It is worked by a horse or horses attached to a long horizontal beam placed under the drum.

Whin—Whin-stone or whin-rock. The Scotch name for hornstone. In Nova Scotia the miners apply this term to a thick-bedded rock composed of grains of quartz with argillaceous or felspathic matter which might be called a greywacké.

Whip—A beam over a shaft, with a pulley and rope for raising or lowering a bucket or kibble. This is done by means of a horse going forward and back again.

Winze—An opening sunk from one level or drift to another, but without extending upward to the surface like a shaft.

Zeolites—A numerous family group of minerals, found chiefly in volcanic rocks. In composition they are allied to the felspars, but contain water in addition.

Zincblende—Natural sulphide of zinc. A crystalline mineral with a bright resinous lustre; generally of resinous or dark color; gives a white streak. See *Blende.*

Zircon—A hard and heavy mineral found in granitic rocks. It consists of silicate of the metal zirconium. The commoner varieties are generally of a reddish-brown color. When transparent it is prized as a gem.

Zone—In geology, used in the same sense as horizon, to indicate a certain geological level or chronological position, without reference to the local attitude or dip of the rock.

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